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INVERTEBRATE PALEONTOLOGY OF THE UPPER PERMIAN RED BEDS OF OKLAHOMA AND THE PANHANDLE OF TEXAS.

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With plates V to VIII.

THROUGH the favor of Prof. E. Haworth the writer was enabled to study the Red Beds of western Oklahoma and the Panhandle of Texas in the latter part of the season of 1904. The locality at Whitehorse spring, eighteen miles west of Alva, Okla., was visited and a collection of fossils secured from the Whitehorse sandstone. In addition to this, the rocks of the Quartermaster formation, now known to form the upper part of the Paleozoic Red Beds, were studied, and a collection made from the sandstone exposed near Dozier, Tex., at a place noted previously by Prof. C. N. Gould. This sandstone is shown in the hills just east of Mr. Caperton's house, which was then the post-office of Dozier. The fossils were found on the west slope of the hill.

On account of unavoidable delays the results of the study of these collections have been postponed to the present time. These collections are of great importance, as they furnish the final evidence that the Red Beds, below the Dockum beds, of the Oklahoma-Panhandle region are Paleozoic in age. Before entering into a detailed discussion of the fauna of these rocks and their relationships and the age of the deposits, it is desirable to give a brief review of previous work upon the subject. Much of this has been given by Prof. W. F. Cummins, in the Second Annual Report of the Geological Survey of Texas, and is liberally quoted below.

1. Published by permission of the Director of the Geological Survey of Kansas.

HISTORICAL REVIEW.

Prior to the work of the Texas Geological Survey and the work of Cope and White, the Red Beds were referred to one system or another on lithologic and stratigraphic evidence alone. The first of these criteria is of very little value when the rocks are as isolated from the ones with which they are correlated as are the western Red Beds. Their stratigraphic position is such that, until fossils were found, and the fact discovered that they are largely conformable with the Permian and Pennsylvanian below was made known, they could be referred to anything from the Permian to the Tertiary. All these possibilities were suggested by one author or another.

About the earliest work done on these rocks was by Dr. C. G. Shumard, a member of the expedition of Capt. R. B. Marcy, in 1852.[2] Shumard made no attempt to assign any age to these beds, but gave sections and descriptions of them. Prof. Edward Hitchcock studied Doctor Shumard's lithologic specimens and notes, and suggested the difficulty in assigning the proper age to them. He stated[3] that "from the 3d of May to June 2, the formation passed over is, as I judge from Doctor Shumard's sections and descriptions, the predominant one along the upper part of the Red river. All the appended sections of Doctor Shumard, except Nos. VI and XI, exhibit the characters and varieties of this deposit. Red clay is the most striking and abundant member ; and above this we have a yellow or lighter-colored sandstone, often finely laminated. As subordinate members, we have blue and yellow clay, gypsum, non-fossiliferous limestone, conglomerate, and copper ore. Overlying these strata is what Doctor Shumard calls 'drift,' which is surmounted by soil. Excepting the gypsum and copper, no specimen of this formation was put into my hands ; and only one petrifaction, which is a coral from the base of No. 4, unless the fossil wood belongs to it."

After discussing the coral supposed to come from "the base of section No. IV" and a piece of fossil wood, he concludes : "Upon the whole, I rather lean to the opinion that

2. Exploration of the Red River of Louisiana, in the year 1852. Published in 1854.

3. Op. cit., p. 145.

these strata may belong to the Cretaceous formation, though it is singular, if such be the case, that the fossil remains are so scarce, since, as we shall see, they occur abundantly in another portion of the field in which the Cretaceous rocks abound."

Prof. Jules Marcou was the first man to refer these rocks to the Permian, though he first referred them to the Triassic. He states:[4] "Immediately after crossing Delaware Mount . . . we met with horizontal beds of red and blue clay that belong to another geological epoch; this new formation corresponding to that which European geologists have agreed to call the Trias." Four years later he thought that a portion of these beds was Permian, and states: "I have always strongly suspected that the New Red Sandstone between Delaware Mount and Beaverton was of Permian age. Having found no fossils, and being the first geologist to enter these regions, I was not able when in the field to declare exactly the age of those strata. All that I knew was that after having left the Carboniferous limestone of Delaware Mount I entered upon another and younger formation, and it was only after having passed Beaverton that I saw clearly that I was upon the New Red Sandstone. Since the discovery of Permian in Kansas I am still more inclined to the belief that the strata between Delaware Mount and Beaverton are Permian. Thus, you see, I include the Permian in the New Red Sandstone."[5]

In a paper on the notes furnished him by Capt. John Pope on a survey from El Paso to Preston he says: "The upper part and the head waters of the Rio Brazos are situated on the rocks of the Trias." "I have since used the more general expression New Red Sandstone formation to designate all the strata in America between the Carboniferous formation and the Jurassic rocks." These statements would seem to indicate that he considered the lower portion of the Red Beds as Permian and those higher up as Triassic. These correlations were based upon lithological and stratigraphical grounds, as stated by Cummins.[6]

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4. Report of Explorations for a Railroad Route near the Thirty-fifth Parallel of Latitude, 1854.

5. American Geology, Zurich, 1858. From Cummins.

6. Sec. Ann. Rep. Geol. Surv. Tex., p. 399, 1891.

"Dr. William De Ryee, formerly state chemist, visited Archer county in 1868, in the interests of the Texas Copper Mining and Manufacturing Company. In a report made to that company, and published by them, he says: 'After traversing the Lyas and Carboniferous series northward of Weatherford, I was agreeably surprised by a grand panorama of the outcropping of the Permian formation. This system is extensively developed in Russia between the Ural mountains and the river Volga, in the north of England, and in Germany, where it is mined for its treasures of copper, silver, nickel and cobalt ores. It has not heretofore been known to exist in this state, or has been mistaken for the Triassic system, which is overlying the former to the northwest.'

"Prof. Jacob Boll, formerly of Dallas, Tex., in an article entitled 'Geological Examinations in Texas,' published in the *American Naturalist*, vol. XIV, pp. 684–686, September, 1880, says that these beds of Texas are undoubtedly Permian.

"Prof. G. C. Broadhead, who visited Colorado City, refers the beds in the vicinity of that place to the Permian."[7]

Professor Boll's statement quoted above probably has its foundation in the collecting and exploring which he did for Professor Cope, and who secured some of the material described by Cope and listed below.

Cope was the first to refer the Red Beds to the Permian, using fossils as evidence of their age. In 1878 he published an article stating that "the discovery of a species of the genus *Clepsydrops* in Texas, in a formation hitherto regarded as Triassic, adds weight to the view above expressed, that the Clepsydrops shales of Illinois belong either to the Triassic or to the Permian formation."[8] In the same year, under the title "Descriptions of Extinct Batrachia from the Permian Formation of Texas," he describes the following species:[9] *Diadectes sideropelicus*, *D. latibuccatus*, *Bolosaurus striatus*, *Chilonyx* (*Bolosaurus*) *rapidens*, *Pariotichus brachyops*, *Pariotichus* (*Ectocynodon*) *ordinatus*, *Clepsydrops natalis*, *Dimetrodon incisivus*, *D. rectiformis*, *D. gigas*, *Eryops* (*Epicordylus*) *erythroliticus*, *Meta-*

7. Taken from Geol. Surv. Tex., 2d Ann. Rep., pp. 399, 400.

8. Proc. Amer. Phil. Soc., XVII, p. 193.

9. Ibid., pp. 505–530. Lists revised after Hay.

mosaurus fossatus, *Empedias* (*Empedocles*) *alatus*, *Embolophorus fritillus*, *Threopleura retroversa*, *T. uniformis*, *T. triangulata*, *Eryops megacephalus*, *Eryops* (*Parioxys*) *ferricolus*, *Cricotus heteroclitus*, *Zatrachys serratus*, *Trimerorhachis insignis*, *Rhachitomus valens*, *Ctenodus periprion*, *C. porrectus*, *C. dialophus*. Based on these fossils, he states the following "thesis," among others: "The horizon of the Clepsydrops shales of Illinois and the corresponding beds in Texas is Permian." Under the title "Second Contribution to the History of the Vertebrata of the Permian Formation of Texas," he adds the following species:[10] *Theopleura obtusidens*, *Naosaurus* (*Dimetrodon*) *cruciger* (described in Amer. Nat., 1878), *Diadectes phaseolinus*, *Empedocles molaris* (ibid.), *Helodectes paridens*, *Parabatrachus* (*Ectosteorachis*) *nitidus*. In 1883 he published his third contribution,[11] adding the following species without discussion: *Edaphosaurus pogonias*, *Pariotichus* (*Ectocynodon*) *aguti*, *Diplocaulus magnicornis*, *Acheloma cumminsi*, *Anisodexis imbricarius*.

In the same volume, on page 628, he publishes his fourth contribution, adding the following species, which he considers as Permian, adding them without discussion of their age: *Parabatrachus* (*Ectosteorachus*) *ciceronius*, *Gnathorhiza serrata*, *Trimerorhachis bilobatus*, *Isodectes* (*Pariotichus*) *megalops*, *Chilonyx rapidens*, *Empedias* (*Empidens*) *fissus*, *Diadectes* (*Empidens*) *phaseolinus*. In the fifth contribution he adds "and Indian Territory" to the title. His additions are:[12] *Ceratodus favosus*, *Cricotus crassidicus*, *C. hypantricus*, *Clepsydrops leptocephalus*, *C. macrospondylus*, *Naosaurus* (*Edaphosaurus*) *microdus*, *Diacranodus* (*Didymodus*) *texensis* (=*D. compressus?*), *D.* (*D.*) *platypternus*, *Embolophorus dollovianus*. In 1892 he remarks that the Dockum beds are Triassic, basing his conclusions on fossils secured from them.[13] In various other places he refers to the lower beds where the fossils were obtained as Permian, the Dockum beds being above the unconformity at the top of the Permian beds. In other papers Cope adds the following species to his list from the Texan Permian: *Pariotichus isolomus*, *Pantylus cordatus*, *P. coicodus*,

10. Ibid., XIX, pp. 35-38, 1880.
11. Ibid., XX, p. 447.
12. Ibid., XXII, pp. 28-47, 1885.
13. Ibid., XXX, pp. 123-131.

Hypopnous squaliceps, Zatrachys microthalamus, Z. conchigerus, Trimerorhachis mesops, Diplocaulus limbatus, Octocœlus testudineus, O. mimeticus, Conodectes favosus, Diadectes biculminatus, Bolbodon tenuitectus, Pariotichus aduncus, Labidosaurus hamatus, Trimerorhachis conangulus, Pariotichus (*Ectocynodon*) *incisivus, Helodectes isaaci, Platysomus palmaris, Ctenacanthus amblyxiphias, Janassa ordiana, Dimetrodon semiradicatus, Naosaurus claviger.*

Aside from Cope's "Contributions," Cummins quotes a statement of his[14] concerning the age of the beds he refers to the Permian, which is as follows: "The Texan genera of this group, so far as known, are equally related to the Ural and South African types. The age of the former deposit is the Permian, which includes, according to Murchison, the Rodthliegende and Zechstein of Thuringia. The age of the South African beds is uncertain, but it is suspected by some authors to be Triassic, and by Owen to be Paleozoic. In discussing the age of the Clepsydrops shales of Illinois, which had been referred to the Coal Measures by all previous investigators, I left the question open as to whether they should be referred to the Permian or Triassic formations. The evidence now adduced is sufficient to assign the formation, as represented in Illinois and Texas, to the Permian. Besides the saurian genera, above mentioned, the existence of the ichthyic genera *Janassa, Ctenodus* and *Diplodus* in both localities renders this course necessary."

In the February number of the *American Naturalist* for 1889,[15] Prof. Charles A. White described the first invertebrates from the Red Beds of Texas. The fossils were from the same horizon as the vertebrates described by Cope, above mentioned. Specimens were first submitted to White by Prof. W. F. Cummins, who did much of the collecting for Cope. White then visited the localities from which the specimens came and, with Cummins, made further collections. He also studied the stratigraphy of the region and published the section made by Cummins, and verified by himself, of the rocks of the region in which the fossils were found. On page 113

14. Geol. Surv. Tex., II, p. 414.

15. XXIII, pp. 109-128.

he says: "The following section of the Texas Permian is taken from Mr. Cummins's field-notes, but it has been in large part verified by my own personal observation. The different members of this section, which are indicated by consecutive numbers, are not distinctly definable from one another, but the section is presented in this form for convenience in making reference to the respective horizons at which collections of fossils have been made." The section follows:

"1. Reddish and mottled sandy clays, with occasional layers of sandstone.

"2. Variously colored clayey and sandy concretionary strata, with a few irregular layers of impure concretionary limestone; embracing near its middle a somewhat persistent limestone of grayish-blue color.

"3. Sandstones alternating with clayey and sandy concretionary layers and a few fine-grained siliceous layers.

"4. Reddish and buff colored clayey and sandy shales, with occasional layers of sandstone.

"5. Sandstones and sandy shales, with beds of reddish sandy clay, passing gradually into the Coal Measures beneath."

"Vertebrate remains, which Professor Cope confidently refers to the Permian, occur at numerous localities and many horizons from the base to the top of this section; but invertebrate remains have hitherto been discovered only in strata which are included in Nos. 2 and 3, respectively, of that section. The lowermost known horizon of invertebrates is about 400 feet above the base of the series, and the uppermost is about as much below the top of the same; that is, the middle 200 feet in thickness of the Permian series as it has been defined."

He then proceeds to give the localities from which the fossils were secured. He then gives a list of thirty-two species from these two horizons, shown in tabular view, from three localities. His list is as follows: *Goniatites baylorensis*, *Ptychites cumminsi*, *Medlicottia copei*, *Popanoceras walcotti*, *Orthoceras rushensis?*, *Nautilus winslowi*, *N. occidentalis*, *N.* three undetermined species, *N.* (*Endolobus*) undetermined, *Nati-*

copsis remex, *N. shumardi?*, *Euomphalus subquadratus*, *E.* undetermined, *Murchisonia* and *Patella* both undetermined, *Bellerophon crassus*, *B. montfortianus* and one undetermined, *Sedgwickia topekaensis*, *Pleurophorus* undetermined, *Clidophorus occidentalis*, *Yoldia subscitula*, *Myalina permiana*, *M. aviculoides*, *M. perattenuata*, *Gervillia longa*, *Aviculopecten occidentalis*, *Syringopora*, *Spirorbis* undetermined, and *Cythere nebrascensis*."

Concerning *Ptychites cumminsi* and *Popanoceras walcotti*, he remarks, "that if they alone, and without any statement of correlated facts, had been submitted to any paleontologist, he would not have been warranted in referring them to an earlier period than the Trias, if he had followed the usually accepted standard of reference." His conclusion is, after an extended discussion of the Permian and Carboniferous of the world: "The evidence upon which the Texan strata have been referred to the Permian is fuller than that which has been adduced with regard to any other North American strata that have been so referred; that is, the evidence of both vertebrate and invertebrate fossils is in favor of such reference, and the difference in the character of the strata from those of the underlying Coal Measures, although not great, is conveniently distinguishable. Still, it is true that the Texan Permian strata bear many Coal Measure invertebrate species, and its flora is at present unknown." *Medlicottia copei*, *Ptychites cumminsi* and *Popanoceras walcotti* are described and figured in this paper. They are characteristic Permian fossils.

In 1891 White republished the fauna just referred to, with descriptions of all the species, and giving four plates of illustrations. The discussion is much the same as was given in the former paper, with some additions, and a general section figured on page 14.[16] The list as revised is as follows: *Goniatites baylorensis* White, *Waagenoceras cumminsi* White, *Medlicottia copei* White, *Popanoceras walcotti* White, *Orthoceras rushensis* McChes.?, *Nautilus winslowi* Meek and Worthen, *Nautilus occidentalis* Swallow, three undetermined species of *Nautilus*, *N.* (*Endolobus*)—?, *Naticopsis remex* White, *N. shumardi* McChes.?, *Euomphalus subquadratus* Meek and Worthen, *E.* ——?, *Murchisonia* ——?, *Patella* ——?, *Bellerophon*

16. Bull. 77, U. S. Geol. Surv., 1891.

crassus Meek and Worthen, *B. montfortianus* Norwood and Pratten, *B.* ——?, *Sedgwickia topekaensis* Shumard, *Pleurophorus* ——?, *Clidophorus occidentalis* Geinitz, *Yoldia? subscitula* Meek and Hayden, *Myalina permiana* Swallow, *Myalina aviculoides* Meek and Hayden, *M. perattenuata* Meek and Hayden, *Gervillia longa* Geinitz, *Aviculopecten occidentalis* Shumard, *Syringopora* ——?, *Spirorbis* ——?, *Cythere nebrascensis* Geinitz.

On page 113 in the former paper and on page 13 of this one, White states, concerning the upper limit of the Texas Permian, that "Along the western boundary of the Texan Permian, as it has been characterized in the preceding paragraphs, a series of strata about 250 feet in maximum thickness, now generally known as the gypsum-bearing beds and thought by some geologists to be of Triassic age, rest conformably upon the Permian. In general aspect, in a prevailing reddish color, and in general lithological character, except the prevalence of gypsum in some of the layers, and the somewhat greater prevalence of clayey material, these overlying beds resemble the Permian beds upon which they rest. With only one known exception, these gypsum-bearing beds have furnished no fossils. The exception referred to is the discovery by Mr. Cummins in Hardeman county, in the upper stratum of those beds, of a thin magnesian layer, containing numerous casts of a species of *Pleurophorus*. This being generally regarded as a characteristic genus among Permian molluscan faunas, and also being a prevailing form in the Permian strata beneath these gypsum-bearing beds, the question is suggested whether the latter ought not to be regarded as constituting an upper part of the Texan Permian. These beds have yet furnished no fossils which can with propriety be referred to the Trias, and it is questionable whether any Triassic strata exist in Texas."

In an article entitled "Report on the Geology of Northwestern Texas," Prof. W. F. Cummins gives a resume of the previous papers on the Permian and other formations of that region,[17] some of which have been referred to above. His discussion of the Permian is rather full,[18] giving twenty-four

17. Sec. Ann. Rep. Geol. Tex., pp. 359-553, 1901.

18. Pages 394-424.

detailed sections and describes the stratigraphy and paleontology. In his introductory sentence to the subject Permian, he says that "It is intended to include in the Permian all the Red Beds in Texas which lie between the upper part of the Albany beds of the Coal Measures and the Dockum beds, or the lower part of the Triassic as recognized here." He thus definitely limits the horizon of the Texan Permian. "That there is a hiatus between these two formations (Trias and Coal Measures) as defined in North America, is a well-known fact. By evidence that will be given hereafter I wish to show that the series of strata that I here call Permian is different from either the Triassic above or the Carboniferous below, as they have been formerly identified." He points out the conformability of the Red Beds and the Coal Measures and the striking unconformity separating them from the Dockum beds or Triassic. In discussing the thickness of these beds, he says: "For quite a while it was thought that the Permian was merely the rounding off of the great Paleozoic area, and that it would only be found in narrow strips along the edge of the Carboniferous formation, but such can no longer be said to be the case, for the Permian has been found in the United States extending over a vast region and is more than 2000 feet thick. In Texas the whole of the beds placed in the Permian are at least 5000 feet thick. These beds must have required a long period of time for their deposition, and the formation is entitled to be represented as a series in geological nomenclature."

He divides these beds into three divisions in ascending order: The Wichita, Clear Fork and Double Mountain beds. The Wichita beds are characterized as consisting of "sandstones, clay beds, and a peculiar conglomerate." There is an absence of limestones. The Clear Fork beds are characterized as limestones, clay and shale beds, and sandstones. The Double Mountain beds are composed of sandstones, limestones, sandy shales, red and bluish clays, and thick beds of gypsum. Sections in the three formations are given and the details of stratigraphy entered into. He states that the Double Mountain beds "lie directly in contact with the Clear Fork beds throughout the whole length, and no attempt has been made to determine a definite line of division between the two divisions.

"Doctor White, . . . described the invertebrate fossils taken from the Wichita beds and the lower part of the Clear Fork beds. . . . Prof. E. D. Cope has described the ver tebrate fossils from the Permian beds of Texas, . . . collected from the same beds as those from which the invertebrates were taken that were described by Doctor White, some of them a little higher in the series."[19]

It is thus clear that the lower Red Beds were clearly established as Permian by Cope, White and Cummins at an early date and the limits established, based on paleontological evidence. In the following part of the discussion of the Permian, Cummins takes up Hay's paper[20] and discusses his theses, or reasons, for referring the Red Beds to the Jura-Trias. A significant remark of Cummins's concerning the correlation of the Kansas beds with those of Texas is that he has traveled as far north as the Canadian river north of Mobeetie, and down the river opposite the lower end of the Wichita mountains, and "seen only the Double Mountain beds. The older beds of the Permian may have been exposed farther northward in Kansas, but I am of the opinion that southwestern Kansas has only the uppermost beds, which Mr. Hay has synchronized with strata near the mouth of the North Fork of Red river. This I judge from Mr. Hay's description of the strata." This is Mr. Cummins's conclusion of the matter, while Hay argued that they were Jura-Trias. On page 408 Cummins states, under the head, "Double Mountain beds": "The fossils recognized [in section No. 19] were two species of ammonite, *Orthoceras* and *Pleurophorus*. The upper part of No. 2 of the above section was almost entirely composed of ammonites."

On page 222 of the fourth annual report, after discussing the correlation of the Texas Permian, he states that "it is still too early to attempt exact correlation, but it is quite probable that the Albany division of the Coal Measures will prove the same as the beds at Fort Riley, Kan.

19. Ibid , pp. 413, 414.

20. Bull. 57, U. S. Geol. Surv., 1890, pp. 23-25.

"Prof. A. Hyatt has published a figure of *Phacoceras dumblei*. This fossil was taken from the very top of the Albany division in Texas. It was also found at Fort Riley, in Kansas; and as the form is supposed to have but a short range in time, it would go far to assist in correlating the strata."

In the light of later work by Adams, to be referred to below, the statement made on page 223 of this paper is of extreme interest; the italics are mine: "North of the Brazos river the Wichita division of the Permian rests directly on the Cisco division of the Coal Measures. In a word, it occupies the same position, stratigraphically, as the Albany division on the south. *It may be that the Wichita and Albany divisions are but different facies of the same formation.* The question will have to be determined by a close study of the stratigraphy."

"If it shall be finally determined that the *Wichita and Albany divisions are but different facies of the same formation, it will at once settle the question of boundary between the Carboniferous and Permian in North America, for there is no dispute about the Wichita beds being Permian.*"

He also states that the fossil flora from the Permian described by Profs. I. C. White and Fontaine were taken from the Wichita division, and that "the flora collected bears out the conclusion that has been so far clearly shown by the vertebrate and invertebrate fossils, that the strata from which it was taken are Permian." He then discusses the Clear Fork division, and states that it probably extends north into Kansas. He then takes up the discussion of the Double Mountain beds. Concerning the age of these, the gypsum-bearing beds, he says: "During the past season's field-work I have traveled across the Permian area twice, and have collections of fossils from several localities in both the Clear Fork and Double Mountain divisions. I have found no fossils higher than the locality already mentioned as the falls of Salt Croton creek, which is within less than 300 feet of the top of the division. As a necessary result, if the beds at the falls on Salt Croton creek can be shown to be Permian, then there can be no dispute as to the beds situated between that and the Wichita being Permian also."

The fossils found by him in the Double Mountain beds are mentioned, as follows: "The fossils from the Double Mountain division were collected at several places. The principal localities were Guthrie, in King county, and the falls on Salt Croton, in Kent county. They are both towards the top of the division. The fossils found are species of *Medlicottia*, *Popanoceras*, *Orthoceras*, *Pleurophorus*, *Goniatites*, *Schizodus*, and others which have not been determined. The finding of these forms at these localities will certainly establish the Permian age of the beds. The *Medlicottia* found in the Double Mountain beds is the form described by Doctor White from the Wichita division, and not the *Sagerceras* described by Gabb from the Triassic of Nevada. The last reason for putting the Double Mountain division in the Permian is, that immediately above, and in unconformable stratification, are beds beyond doubt Triassic."

In a paper read before the Texas Academy of Science in 1897[21] Cummins gives a resume of the detailed work of the latter portion of the Texas survey, which is of so great interest that it is necessary to repeat some of it here. As quoted above, he had divided the Permian rocks into three divisions, and the Coal Measures had been divided into five, "for facility in giving particular descriptions of the different beds. It was understood at the time that these divisions were made that they were provisional, and subject to revision when their true relationship to each other might be determined." After discussing the statements made repeatedly in the Texas reports that the Wichita and Albany divisions occupied about the same position stratigraphically, and the statements quoted above, that they might be but different facies of the same formation, he states that "*by walking along the outcrop every foot of the way we were enabled to note the gradual change in the lithological character of the bed.*[22] We were also enabled to note the gradual extinction and change in the fossils as the beds changed in composition.

"We found that a limestone in the Albany division with an abundant and characteristic Coal Measures fauna gradually changed in composition to a calcareous sandy clay entirely

21. Texas Permian, June 15, 1897, pp. 93-98.

22. Italics are mine.

destitute of fossils of any kind. Other limestone beds in the Albany division when traced northeastward would gradually pass into sandstone, while others would entirely disappear."

He then discusses in detail the gradual changes in lithological characters and the corresponding changes in the fauna, and states that by "thus tracing the escarpment between the two points, the Clear Fork of the Brazos river and the Big Wichita river, and finding it continuous, we demonstrated very clearly that the beds called the upper part of the Albany division in the previous reports are the same as those called the upper part of the Wichita division in the same reports."

After making these discoveries he includes the Albany division in the Wichita, calling it all Wichita, as they are synchronous. He closes the paper by correlating the basal Permian of Kansas and Texas in this manner: "The *Phacoceras dumblei* Hyatt has been found only along a very narrow horizon in the Texas Permian. That horizon was traced and the fossils found for a distance of seventy-five miles. The fossil was found quite numerous at places, so that it might be said that the bed was characterized by that fossil. This fact will assist materially in correlating the Texas and Kansas beds, as that fossil has been reported only from one locality in the Kansas area, where it is associated with the same fossils as in Texas. It is quite certain that the Fort Riley horizon is the same as the Wichita division in Texas, and is at the very top of the division. . . ."

In 1892 Dumble and Cummins visited the Double mountains and made a careful section of the rocks there, which may, perhaps, be taken as typical of the summit of the southern Red Beds and their relation to the Triassic. The Double Mountain section is as follows:[23]

			Feet.
Lower Cretaceous.	1.	Caprina limestone	40
	2.	Comanche Peak series	55
	3.	Trinity	25
Trias	3*a*.	Dockum	35
Permian	4.	Shaly clay, underlaid by red or terra-cotta sandstone,	105
	5.	Upper gypsum beds	60
	6.	Middle gypsum beds	75
	7.	Lower gypsum beds	135

Concerning the relation of the Dockum beds of the Triassic

23. Dumble and Cummins, Amer. Geol., IX, pp. 347-351, June, 1892.

to the underlying Double Mountain beds of this section, they say: "Underlying the conglomerate last mentioned (Dockum beds), but separated by a bold unconformity, we find five feet of sandy clay dipping toward the northwest. It is underlaid by a red or terra-cotta sandstone, somewhat mixed with clay toward the top and bedded in layers which vary in thickness from one foot to an inch or less. There are two seams of impure limestone embedded in the sand, but although a careful search was made for fossils none were found.

"The red or terra-cotta sandstone rests directly upon the upper gypsum beds, which consist of an upper layer of gypsum underlaid by yellow and red sandy clays or shales which are much cross-bedded. Gypsum also occurs throughout the clays."

This is followed by a brief description of the remaining gypsum beds. No fossils were found in the Triassic or Permian beds at this place.

In the Second Annual Report of the Texas Survey[24] N. F. Drake describes the area and stratigraphy of the Dockum beds overlying the Permian in western Texas. In this paper he graphically describes the unconformity between the Triassic and Permian beds, and brings out the fact that the Dockum beds are fresh-water deposits, as instanced by the *Unio* invertebrate fauna and the shallow-water vertebrate fauna described by Cope in the article following Drake's.

The foregoing quotations are sufficiently complete to require but little comment here. They demonstrate the thoroughness with which the Texas survey worked out the geology of these deposits, and, as will be shown later, they correspond well with the more recent work to the northward.

In 1892 Tarr published an article on the Texas Permian[25] in which he discusses the general syncline in which the south ern part of the Red Beds lie. His conclusion is that the Red Beds were laid down in an inland sea. He says that "the Permian conditions are, therefore, foreshadowed in the Car· boniferous, and probably, also, the conditions which cul minated in Permian times in the completely enclosed dead

24. Pages 227-247, 1892.

25. Amer. Jour. Sci., XLIII, pp. 9-12, 1892.

sea were in Coleman times [Upper Pennsylvanian] indicated by the gathering in of shore-lines and the partial enclosure of a mediterranean sea. . . . In summary it may be said that the object of this paper is to show that the Permian of Texas is, like other areas of the Permian, such as those of Europe, a deposit in large measure made in an inland sea, at certain times in its history a dead sea. . . ."

To a large extent I agree with these statements, though it will have to be understood that this inland sea was open somewhere occasionally to admit the foreign elements of the fauna which appear in the lower part, as well as that of the Whitehorse sandstone and the Quartermaster beds, at two distinct periods in its late history. Similar opinions have been expressed by others in accounting for these beds.

This brings the discussion of the Texas beds down to the last few years. I have not cited all the papers written on this subject in the preceding pages. However, I have endeavored to discuss much of the more important material bearing on the Texas Permian, confining myself largely to the work of those who have made the most careful and extended observations in the field and who have contributed the most evidence bearing on the age of these beds. Some of the statements quoted will be discussed in the light of later knowledge, in the proper place.

While the explorations were being carried on in Texas the Kansas geologists were endeavoring to solve the same problems in Kansas. This work has been so thoroughly summarized by Prosser[26] that it will be unnecessary to give it here. On account of differences in lithologic characters between the Red Beds of Texas and Kansas and the unexplored region of great extent lying between them, it was impossible to determine the age of the Kansas beds without fossils, which have been, so far, lacking. This region had been hurriedly crossed by Cope, who was inclined to the opinion that the Kansas beds and those of Indian Territory [now Oklahoma] were Permian, yet he was not certain enough of it to make the declaration without reservation.

Within the last decade much light has been thrown on this

26. Univ. Geol. Surv. Kan., II, pp. 55-95 1897.

subject, with the result that the age of the Kansas and Oklahoma beds is pretty well understood. Cragin, Gould, Adams and Kirk are the ones to whom we are principally indebted for the field-work, and Williston and Case for the determination of the vertebrates. My knowledge of the stratigraphy of the Red Beds of Oklahoma is too limited to enter into a detailed discussion of the merits and value and synonomy of the various formational names proposed for the horizons of Kansas and Oklahoma, and I will content myself with keeping track of the larger divisions only, which, in the main, concern us here.

In 1897 Prof. F. W. Cragin published an article entitled "Observations on the Cimarron Series,"[27] in which he gives the results of a trip across the territory of Oklahoma. In this paper he shows that the horizon of the large gypsum beds extends into southern Oklahoma and Texas. Cragin here refers all the Kansas Red Beds to the Permian, on stratigraphic evidence, which, however, is much stronger than that upon which most of the previous opinions concerning the age of these beds was based. The bulk of the paper is concerned in the minutiæ of the stratigraphy of these beds and a revision of their classification.

In 1898 Adams made a trip into Oklahoma from southern Kansas, and gives a brief description of the trip and its results in an article in the *Kansas University Quarterly*.[28] He describes the appearance and features of the Red Beds in three counties, including the Glass mountains. He gives a reconnaissance map of the region.

Gould published a statement showing the change of the Wellington shales into red strata, near Vardin, Okla.[29]

In 1900 Gould, with two other members of the Oklahoma survey, made an extended trip into the northeastern part of the territory,[30] for the purpose of determining the nature of the Upper Pennsylvanian and Lower Permian of that region. In the article mentioned he shows how the limestones and

27. Amer. Geol., XIX, pp. 351-363, 1897.

28. A Geological Reconnaissance in Grant, Garfield and Woods Counties, Oklahoma. Kan. Univ. Quart., VII, pp. 121-124, 1898.

29. Kan. Univ. Quart., 1900, pp. 175-177.

30. Notes on the Geology of Parts of the Seminole, Creek, Cherokee and Osage Nations. Amer. Jour. Sci., XI, pp. 185-190, 1901.

shales of the top of the Pennsylvanian and the Wreford limestone and associated formations finally give place to reddish sandstones and shales similar to those of the Red Beds above, just as Cummins had shown them to do in Texas on passing northward. He sums up the results of the trip as follows: "1. The Flint Hills do not extend as far south as the Seminole country. 2. The sandstone which is well developed in the eastern part of Chautauqua county, Kansas, continues uninterruptedly southward east of the Flint Hills, beyond the North Canadian river. 3. The eastern limit of the Red Beds in southern Oklahoma is not far from the western part of the Seminole country. . . ."

Adams made a trip in this region and east of it, coming to much the same conclusion as Gould, but giving a map illustrating the change in color and lithology of the formations.[31] In this paper Adams states that the sections of Gould and Drake were taken as cross-sections of the rocks and did not permit of accurate correlation. While some of Gould's sections were taken at points where the correlation was uncertain, yet this criticism probably was not intended to apply to Gould's paper as a whole, for the stratigraphy of the northern region bears the evidence of being correct, and the horizons of the upper part properly correlated, and, furthermore, it corresponds with Adams's correlations as shown on his map.

In another place[32] Gould describes how the Marion and Wellington formations change from light-colored calcareous and argillaceous beds to more arenaceous red sediments like the overlying Red Beds. These accounts of his give us a very fair idea of the lithologic changes taking place in the southern extension of the Kansas Lower Permian. He describes the passage of the Gypsum Hills from Kansas into Texas, the result of his work on the Oklahoma survey in the same year,[33] showing that the upper Red Beds are the same in the three states.

Adams published articles in *Science* and the *Bulletin of the*

31. Carboniferous and Permian Age of the Red Beds. Amer. Jour. Sci., XII, pp. 383-386, 1901.

32. On the Southern Extension of the Marion and Wellington Formations. Trans. Kan. Acad. Sci., XVII, pp. 179-181, 1901.

33. Amer. Geol., XXVII, pp. 188-190, 1901.

Ge logical Society of America, concerning preliminary studies in Texas[34] on the relationship of the Red Beds to the limestones and shales to the southward. He states his reconnaissance work confirms the detailed work of Cummins in showing the Albany and Wichita beds to be different facies of the same horizon as quoted above. On page 198 of the last reference cited, under the caption "obsolete terms," Adams states: "Concerning the terms Wichita, Clear Fork, and Double Mountain, it may be said that there is little reason to believe that they should be any longer retained, since they have no stratigraphic significance." The retention of these terms is a necessity until, by further work, it can be shown that a better general classification is available. Had any detailed work been done showing the necessity of any changes in formation names, or showing any inaccuracy in the later detailed work of Cummins, the situation would be very different.

Four publications have added an inestimable amount to our knowledge of the geology of Oklahoma and the Panhandle of Texas. The first of these is the Second Biennial Report of the Department of Geology and Natural History of the Territory of Oklahoma. In it are two articles bearing on the subject under consideration. The first of these is the "General Geology of Oklahoma," by Gould.[35] In this paper he gives a brief review of previous literature and then describes in fair detail the geology of the territory. He discusses the manner in which the lighter deposits to the north dissipate into red deposits of the territory, agreeing with Adams that the eastern extremity of these beds are Pennsylvanian. He then gives the classification of Cragin, and shows how it is necessary to revise it on account of conditions found in Oklahoma which are not exhibited in the northern extremity of the formations in Kansas. His section is given below. He gives Cragin's classification and his own modified to meet

34. Sci., XV, pp. 545, 546; XVI, p. 1029, 1902. Bull. Geol. Soc. Amer., XIV, pp. 191–200, 1903.

35. Pages 17–74, 1902.

the knowledge of the Oklahoma deposits at that time.[36] The table follows:

Cragin's classification.		Classification used in this report.
	QUARTERMASTER DIVISION.	——
		——
Big Basin sandstone.	GREER DIVISION.	Delphi dolomite.
		Collingsworth gypsum.
		Cedartop gypsum.
		Haystack gypsum.
		Kiser gypsum.
Hackberry shales.		Chaney gypsum.
Day Creek dolomite.	WOODWARD DIVISION.	Day Creek dolomite.
Red Bluff sandstones.		Red Bluff sandstones.
Dog Creek shales.		Dog Creek shales.
Cave Creek gypsums.	BLAINE DIVISION.	Shimer gypsums.
		Altoona dolomite.
		Medicine Lodge gypsum.
		Magpie dolomite.
Flower-pot shales, upper part.		Ferguson gypsum.
Flower-pot shales, lower part.	NORMAN DIVISION.	——
Cedar Hill sandstones.		——
Salt Plain measures.		——
Harper sandstones.		——

"The term 'division' is here used in a general sense, corresponding with its ordinary English meaning, to designate a larger or smaller sequence of strata which may in one instance correspond to a formation having a simple and uniform lithologic character, or in another to a group of such formations."

In discussing the Norman division, which is not differentiated in the section, he states that "the rocks of the Norman division consist chiefly of brick-red clay shales, with some interbedded ledges of red and white sandstone. In the eastern part of its visible extent sandstone predominates, while in the region along the base of the Gypsum Hills the beds consist almost wholly of clay.

"The Norman division may be divided on lithological grounds into three general districts, as follows: An eastern district, in which the sandstones are of sufficient thickness to form prominent ledges; a central district, in which the sandstones are thinner and consequently less conspicuous; and a western district, in which the sandstones are practically wanting. It is impossible, in the present state of our knowl-

36. Loc. cit., p. 42.

edge, to draw lines of separation accurately between these districts, and for this reason the strata are not herein defined and named as separate formations.''

The remainder of the divisions are sufficiently subdivided for our purposes as given in the above table. Each of the subdivisions is described and their extent indicated in the text. Following the part on geology is an extensive report on the gypsum of Oklahoma, containing many points of interest to the stratigrapher, especially since the gypsum beds form the principal relief of the upper Red Beds. In the geological part of the report the paleontology of the territory is discussed, and will be referred to later.

The second of the four papers is the third biennial report of the same survey. I have already reviewed this report,[37] and will merely call attention to the point of interest to us here. Kirk traced the Wreford limestone of Kansas, and the sandstone (Payne) into which it dissipates, from southern Kansas to the vicinity of Norman. It will be seen that the strike of it is such as to pass around the east side of the Wichita mountains, if traceable all the way, and arrive near the outcrop of the Wichita formation of Texas. It is a matter of considerable importance and it is to be hoped that the Oklahoma geologists will soon be able to trace it out, as it would form an unimpeachable connecting link between the Kansas and Texas Permian. This sandstone lies in the lower part of the Norman division.

The third of these papers is the ''Geology and Water Resources of Oklahoma and the Eastern Panhandle of Texas.''[38] In this paper we have the first geological map of the territory, accompanied by a discussion of the formations represented, which seem to be worked out with considerable care for a reconnaissance map, and add greatly to our knowledge of the region. The manner of the gradation of the Kansas light Permian into the red shales and sandstones is shown on this map, the gradual replacement taking place soon after crossing the boundary line.

37. Amer. Geol., XXXV, p. 390, 1905.

38. U. S. Water-supp. and Irr. Pap., 154, 1906.

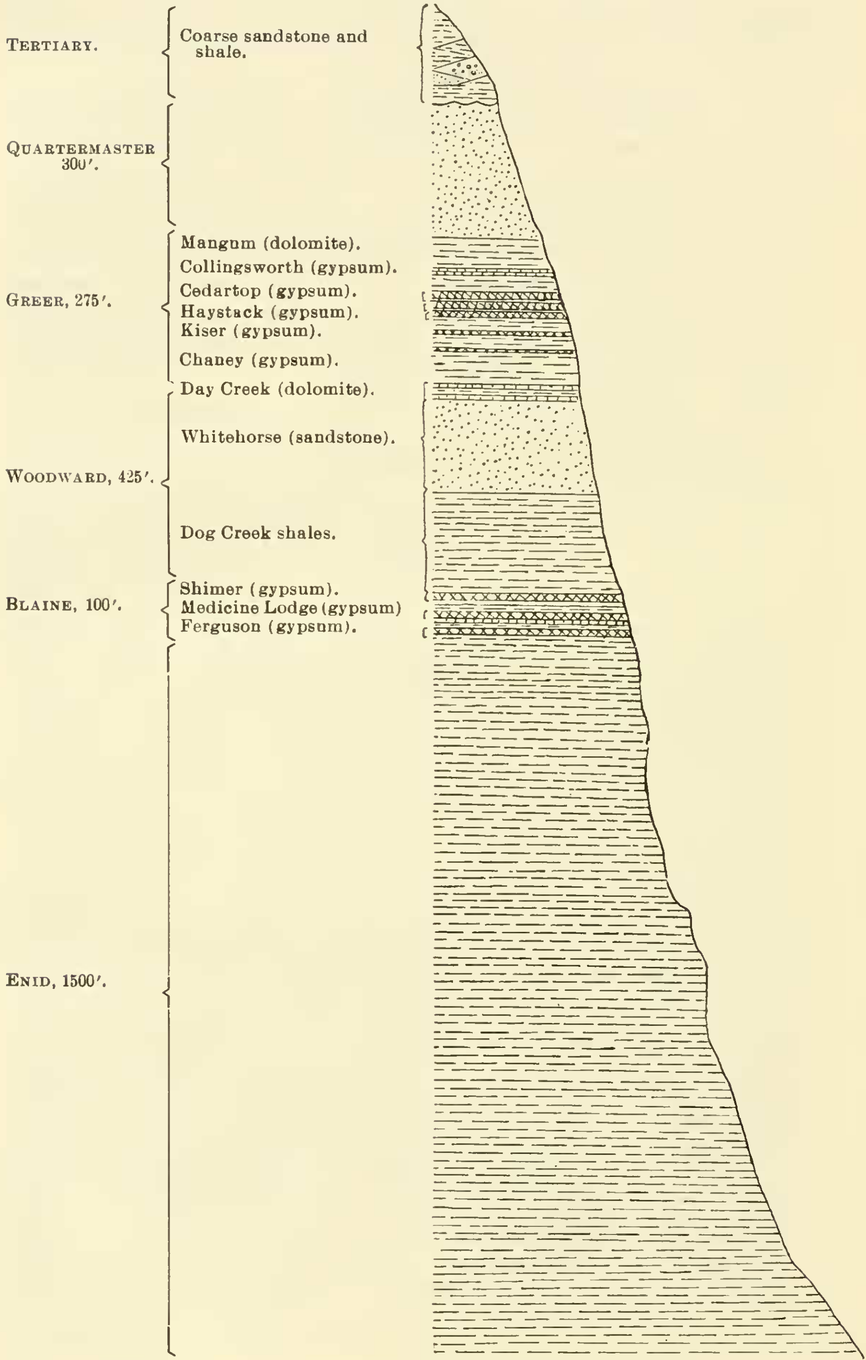

FIG. 1.—General section of the rocks of Oklahoma. Redrawn after Gould.

There are a few changes in the classification used in this paper from the preceding ones. In the present classification it is seen that the gypsum beds and the groups of gypsum beds, which form the salient topographic features of the country, play an important part. They are separated by successions of sandstones and shales and dolomites. It will be seen from the above cut that Gould has replaced the term "Norman" with "Enid," limiting it thus: "The Enid formation includes all the rocks of the Red Beds from the base of the Permian to the lowermost of the gypsum ledges on the eastern slope of the Gypsum Hills. The top of this formation, however, is not a plane, since the gypsum beds which mark its topmost limits are found to be more or less lenticular when traced for long distances. The Enid comprises all of the Harper, Salt Plains and Cedar Hills members of Cragin's first paper, and the Kingfisher and Glass Mountain formations of his second paper. It is named from the county-seat of Garfield county."

It will be seen that the Enid differs from the Norman as previously defined in excluding the rocks referred to the Red Beds which are the equivalents of the Pennsylvanian rocks below the Permian; hence, probably, the reason for substituting the second term. The general section gives an adequate idea of the stratigraphic succession and the groupings. The invertebrate fossils mentioned in this paper were taken from the Whitehorse sandstone and the upper part of the Quartermaster division.

In the "Geology and Water Resources of the Eastern Panhandle of Texas," Gould carries the mapping west to the foot of the Staked Plains and discovers the Dockum beds lying unconformably upon the top of the Quartermaster formation,[39] but pinching out to the north and not extending into Kansas. Neither are they represented in Oklahoma.

The Dockum beds may extend, in local patches beneath the later rocks, into southwestern Kansas, but are not exposed at the surface.

Perhaps the first article to appear on the vertebrate paleontology of Oklahoma was by Williston, entitled "Notes on the

39. U. S. Water-supp. and Irr. Pap., 154, 1906.

Coracoscapula of *Eryops* Cope,"[40] which was taken from the Enid division, the part probably corresponding to the Wellington formation, as pointed out by Gould. T. Rupert Jones had previously referred the species of crustacean found with the bones at the McCann quarry provisionally to *Estheria? minuta*, abundant in the Triassic system. However, it is only fair to say that the material was so poor that no positive determination could be made. In the discussion of the paleontology of the Red Beds, Gould gives a list of fossils from Orlando from about the same part of the Enid beds.[41] They are *Diplocaulus magnicornus* Cope, Diadectidæ, Gen. Indt., *Pariotichus incisivus?* Cope, labyrinthodont, *Trimerorhachis*. This list was furnished by Doctor Williston as a preliminary one. Concerning it he says: "*Diplocaulus* is an amphibian. The genus occurs in the Permian of Illinois and Texas, according to Cope. The Diadectidæ is a family of theromorph or theriodont reptiles, known only from the Permian of Texas. *Pariotichus incisivus* Cope, from the Permian of Texas, belongs to a family closely allied to the Diadectidæ. *Trimerorhachis* is a genus of stegocephs, from the Permian of Texas.

"All together, you see that these fossils point unmistakably to the Permian. . . ."

Case, in the same paper[42] gives a list and descriptions of fossils occurring at the Orlando locality and makes the following comment: "The collection is of especial interest as it shows a close relationship, both in its forms and its manner of fossilization, to the deposits of northern Texas. Still more interesting is the discovery of forms having the same character of neural and hæmal spines as are found in the forms from the Carboniferous of Linton, Ohio, and in the Permian deposits of Ireland and Bohemia. Two or three forms, as *Trimerorhachis* and *Diplocaulus*, are common to this region and the deposits of Illinois, but the fauna is much more closely related, as is to be expected, with that of the Texas Permian. It is perhaps worthy of note that there is a notice-

40. Kan. Univ. Quart., VIII, pp. 185, 186, pll. XXVI, XXIX, XXX, 1899.

41. Sec. Bienn. Rep. Oklahoma Dept. Geol. and Nat. Hist., p. 60, 1902.

42. Ibid., p. 62.

able difference in the fauna of Illinois and Oklahoma and Texas." Following is the list as given by Case: *Sagenodus?* sp., *Diplocaulus magnicornis?* Cope, *Diplocaulus limbatus?* Cope, *Diplocaulus salamandroides* Cope, *Trimerorhachis* sp. Cope, *Trimerorhachis leptorhynchus* Case, *Cricotus* sp., *Cricotillis brachydens* Case, *Eryops megacephalus* Cope, *Crossotelos annulata* Case, *Naosaurus* sp., *Embolophorus?* sp., *Pariotichus ordinatus* Cope, *Pariotichus* sp., *Pleuristion brachycœlus* Case, *Diacranodus* (*Pleuracanthus*) *compressus?*. According to Cope, Williston, and Case, these fossils demonstrate unmistakably the Permian age of the strata from which they were taken. Case states, after having described the vertebrates from the base of over 2000 feet of the strata, that "the result of the determination of these fossils has been to settle the long-mooted question of the age of the Red Beds."[43]

A remark concerning the horizon of some vertebrates described from the Kansas strata is to the point here. Williston described a specimen from Cowley county, Kansas,[44] in 1897, which he states "clearly belongs to the genus *Cricotus*, and is closely allied to the typical species described by Cope from the Permian of Illinois. His description applies so well to the specimen in hand that I use his language, amended." "A single dorsal vertebra, and, perhaps, some phalanges, belong clearly to the genus *Clepsydrops* Cope, as originally described from Illinois. . . . Associated with these remains are numerous teeth and spines of *Pleuracanthus* (*Didymodus?*) and the plates of a ganoid fish.

"All together, we have here an interesting series of forms, so closely resembling the species described by Cope from Danville, Ill., that I cannot distinguish them specifically. It would seem to demonstrate the contemporaneity of the two formations, and also that of the Texas Permian, whence the species of all these genera have been described by Cope."

These bones were taken from the Garrison formation, south of Dexter, Kan., about fifty feet below the base of the Wreford limestone, which is taken as the base of the Permian by the Kansas geologists. Another very interesting discovery

43. Op. cit., p. 68.

44. Trans. Kan. Acad. Sci., XV, pp. 120-122, 1898.

is brought to light by Doctor Williston in the description of labyrinthodont remains which seem to belong to a genus not heretofore known below the Triassic, from a horizon about 200 feet below the horizon of the Dexter bones, in southern Pottawatomie county, Kansas.[45] These remains were provisionally referred to the genus *Mastodonosaurus*.

These vertebrates are considered to be quite as ephemeral as any invertebrate species, and equally good, for that reason, for purposes of correlation. In the light of these facts, it would seem that the base of the Wichita division of Texas might be somewhere in the neighborhood of the horizon of the Garrison formation of Kansas. This has an interesting bearing on the location of the line of division between the Pennsylvanian and Permian of Kansas, and, together with published data on the plants and the known invertebrate fauna, go to demonstrate that the base of the Permian has not been placed too high by the Kansas geologists in using the Wreford limestone as its lowermost formation.

In April, 1902, the present writer published a note with the figures of some fossils from the Whitehorse sandstone, eighteen miles west of Alva, Okla. The species mentioned were *Bakewellia* (referred provisionally to *Cyrtodontarca*) *gouldii*, *Conocardium oklahomaensis*, *Aviculopecten vanvleeti*, *Naticopsis* sp., *Pleurotomaria* sp., *Dielasma schucherti*, and *Schizodus* sp. After a brief discussion of the fauna, the following statement is made: "Taking all this into consideration, there can be but little doubt that the age of these beds is Permian."

It is interesting to note that work in the Rocky Mountain region is showing similar results to those obtained near the foot of the high plains to the eastward. Cross and Howe have recently carefully described the unconformity between the Triassic Red Beds and the underlying beds, supposed to be the Permian, in Colorado. Drake described this unconformity to the west of the Llano Estacado, and Williston has discovered a rich Triassic vertebrate fauna from the upper Red Beds of Wyoming, while Knight showed that the lower portion of them were Permian. Herrick found Permian invertebrates in the lower Red Beds of New Mexico. These

45. Kan. Univ. Quart., VI, pp. 209, 210, 1897.

discoveries are of especial interest, giving us an idea of the great extent of the Permian sea in America.

SUMMARY.

The foregoing has shown the following facts to be ascertained to date. Cope, Cummins and White have demonstrated that the Wichita (including the Albany) and Clear Fork beds of Texas are unmistakably Permian.

Cummins showed, by mention of fossils, that the beds above to within about "300 feet" of the top of the Red Beds (below the Dockum beds) of Texas are Permian. This would be to about the horizon of the Whitehorse sandstone of Oklahoma.

Cragin and Gould have shown on stratigraphic grounds that the gypsum-bearing beds of Kansas, Oklahoma and Texas are, in a general way, equivalent.

Cummins, Adams and Gould have demonstrated that the light-colored Permian rocks of Kansas and Texas have their equivalents in the red strata of Oklahoma.

Williston and Case have demonstrated that the lower Enid formation of Oklahoma is Permian and of similar horizon to some parts of the Wichita and Clear Fork divisions of Texas.

Beede has shown that the beds as high as the Whitehorse sandstone of Oklahoma are Permian.

Gould has shown that the Whitehorse sandstone is identical with Cragin's Red Bluff formation of Kansas.

FAUNA OF THE WHITEHORSE AND QUARTERMASTER SANDSTONES.

In the present paper the fauna of the Quartermaster division is added to that of the Whitehorse sandstone. As Gould has pointed out, the Quartermaster division is the highest formation in the Red Beds, and the fossils came from well up in this formation.

The fauna of the Quartermaster beds is different in some respects from that of the Whitehorse sandstone, several new elements having been introduced. The literature at hand is unsatisfactory concerning three species of the gastropods of this formation, notably *Naticella.* In order that no possibility of mistake be made, the types of the whole Quartermaster fauna, as here illustrated, were sent Mr. T. W. Stanton, who stated that they were unmistakably Paleozoic.

It was unfortunate that the entire type collection (except two specimens) of the Whitehorse sandstone as figured in the first bulletin of the Oklahoma survey was destroyed in the fire which consumed Science hall at the University of Oklahoma. In order that there might be specimens for comparison as near the types as possible, and collected from the type locality, I have figured here a new set, which are now in the museum of the University of Kansas.

The fossils upon which this paper is based were collected by the writer in the summer of 1904. Those from the Whitehorse sandstone were taken from Whitehorse spring, some two miles or more southeast of Whitehorse post-office, and eighteen miles due west of Alva, Okla. They were taken from the top of the hill just west of the spring. Those from the Quartermaster division are from the sandstone rolled down on the west side of the "Dozier mountains," east of Mr. Caperton's place (then the Dozier post-office), fifteen miles south or southwest of Shamrock, in the Panhandle of Texas.

The faunas are somewhat heterogeneous as to origin. Some of the species seem to be directly derived from the Kansas Permian or Pennsylvanian, while others, as pointed out in the discussion of the species, are derived from the European Permian, especially that of Russia. There seems to be comparatively little resemblance to the Indian or Chinese forms. The fossils described as *Dielasma schucherti* Beede seem to have their closest allies in the Productus limestone of India, the only species, perhaps, with pronounced Indian affinities.

The following fossils have decided American affinities and may be the progeny of the fossils of the older rocks of the western Mississippi valley. These species are: *Pseudomonotis*, *Solenomya*, two species of *Edmondia* (perhaps), *Myalina*, *Schizodus* (two species), *Aviculopecten* (two species), *Pleurophorus*, *Pleurotomaria agnostica*, *Trepospira haworthi* (has affinities both in American and in Kulogory, Russia), *Loxonema*, *Orthonema* (two species), *Bulimorpha*, and *Strophostylus permianus*. Those of foreign affinities are: The *Cyrto-*

dontarcas, both foreign and American, but probably more closely related to the American forms, *Pleurotomaria capertoni* (Oka-Kljsama or England), *Worthenopsis depressa* (England), and Oka-Kljasma Becken, *Murchisonia collingsworthensis* (Donnez basin), *Naticella transversa*, to the Carboniferous of Belgium and the Urals and Triassic of St. Cassian. It is to be held in mind that these affinities may be largely superficial, as the preservation of the specimens is such as to obliterate many of the critical characters. However, a comparison of plate IV of Jakowlew's paper on the "Fauna Einiger Oberpalæozoischer Ablagerungen Russlands" with the last plate of this article can not fail to impress one with the similarity in general aspect.

The gastropods of the Dozier beds appear to have their closest foreign affinities with the Upper Permo-Carboniferous and Lower Permian faunas of the Oka-Kljasma Becken and Kulogory of Russia, as shown by Jakowlew in the paper cited above. The pelecypods seem closely related to the fauna of the Donnez basin. *Cyrtodontarca*, described by Jakowlew, is not identical with any of the American species, being more robust and having a slightly different type of dentition. It is perhaps more closely related to *C. gouldii*, or *C. multidentata*, than to the other species.

This Russian fauna is from a much older horizon than the species described in this paper. It possesses such peculiar relationships that they deserve wider discussion than the scope of this paper permits, and will be taken up more fully in another paper now nearly ready for the press. It is composed of at least two distinct elements, one of which is very closely related to the Upper Pennsylvanian of Kansas and the Middle West, and containing several species in common, such as *Michelinia eugeneæ* White, *Lophophyllum profundum* Milne-Edwards and Haime, *Aviculopecten carboniferus* Stevens, *Entolium aviculatum* Swallow, *Pleurophorus oblongus* Meek, *Schizodus wheeleri* Swallow, *Edmondia aspenwallensis* Geinitz, and *Pleurophorus subcuneatus* Meek, a Lower Permian species of Kansas. Then there is *Cyrtodontarca bakewellioides* Jakowlew, related to three species referred to this genus from the Whitehorse and Dozier sandstones, but specifically distinct from them.

The fact that none of the Russian species are identical with any of the Red Beds species and the identity of several of the Russian forms with the Pennsylvanian species found in the rocks below the Red Reds seems to argue a slow migration of the Upper Pennsylvanian fauna to the Russian provinces and a slower migration of the Lower, Middle and Upper Permo-Carboniferous and Lower Permian faunas to the Oklahoma-Texas region. The time lapse of the latter migration is represented by about 2000 feet of strata in the Red Beds region.

The concurrence of *Conocardium* in these rocks is almost anomalous. I know of but one other place where this genus is represented in the Permian, and that is a very different type of shell found in the province of Palermo, Sicily. The genus is, so far, unknown from the uppermost Pennsylvanian and lower Permian of Kansas.

The tabulation (page 146) gives the known species from the Red Beds. Those of the Enid formation of Oklahoma are placed in the same heading with the ones from the Wichita and Clear Fork of Texas. Careful detailed stratigraphic work will probably show that the Texas and Oklahoma fossil beds are not from exactly the same horizon as hinted at by Case.[46] However, they may be combined, if it is understood that it is merely to serve as a convenience here, and that the correlation is only intended in a general way.

Gould[47] interprets Adams's statements[48] concerning the identity of the Albany-Wichita beds as referring them to the Pennsylvanian. On the other hand, I am inclined to consider the statements as non-committal as to whether they are to be classed as Permian or Pennsylvanian. Cummins,[49] after demonstrating their identity, unhesitatingly referred them to the Permian. The paleontological evidence certainly bears him out in his conclusions.

In a letter from Professor Gould, under date of November 5, 1906, he gives additional and very good reasons for referring the Wichita-Albany beds to the Pennsylvanian. He

46. Loc. cit., p. 62.

47. Water-supp. and Irr. Pap., 154, p. 17.

48. Bull. Geol. Soc. Amer., XIV, pp. 191-200, 1903.

49. Tex. Acad., loc. cit.

states concerning the southwestward extension of the Wreford limestone (and Payne sandstone), previously mentioned, as traced out by Kirk, that "it crosses the South Canadian river at Purcell and is still trending southwest. If it continued, this would just about bring it in strike with the top of Cummins's so-called Wichita beds. The Red Beds of Oklahoma as far west as this line are probably Pennsylvanian." The last statement is based on paleontologic evidence.

If the horizon of the Wreford limestone should correspond to the upper Wichita, it would make the Kansas vertebrates described by Williston of similar horizon with the same fossils from Texas. It would agree very well also with the discovery of a Permian flora in Kansas below the Wreford limestone.

However, whether the Wichita beds are below or above the Wreford limestone, they must, it seems to me, be considered as Permian on paleontological evidence of great weight. In event the Wreford limestone should prove to be in the horizon of the upper Wichita division, the fact that *Phacoceras dumblei* Hiatt would then occur in a much higher horizon in Kansas than in Texas might be explained by the difficulty this clear water (limestone) species would have in getting through the muddy, irony waters of the intervening region, now occupied by red clays and sandstones. However, this must be regarded as pure speculation until our knowledge of the stratigraphic relationship of the two regions is much more complete.

It is necessary to say a word here regarding what are frequently mentioned as "Coal Measures species" and "Pennsylvanian species" in the Permian. They almost invariably refer to certain vigorous forms of great stratigraphic range, such as *Productus semireticulatus*, *Seminula argentia* and several others. Such cases are parallels, though with more restricted range, with *Leptæna rhomboidalis*, *Atrypa reticularis*, and others of the older rocks. When species of this character occur in the Permian rocks they deserve no more consideration than the occurrence of the latter two species when they occur anywhere within their known range. If we apply the laws of evolution to cases where continual sedimentation takes place through great lengths of time, we should expect to find faunal changes very gradual, especially in a nearly isolated epicontinental sea, though it be of great dimensions.

There seems to be little reason, therefore, for considering all sediments laid down in unbroken succession in a given region as belonging to the same period, because the faunal changes, like the stratigraphic changes, are gradual. It is unnecessary to point out here striking and well-known examples of such occurrences.

Aside from the fossils given in the tables, Doctor Gould has forwarded me several specimens of dolomite with *Pleurophorus* sp., and *Schizodus* sp., the latter very similar to one of those described later. These are not sufficiently well preserved to be identified with certainty and are omitted.

SPECIES.	Enid-Wichita.	Whitehorse.	Quartermaster.
Paralegoceras baylorensis (White)	x		
Waagenoceras cumminsi White	x		
Medlicottia copei White	x		
Popanoceras walcotti White	x		
Orthoceras rushensis McChesney?	x		
Temnocheilus winslowi (Meek and Worthen)	x		
Tainoceras occidentalis (Swallow)	x		
Nautilus ——?	x		
——?	x		
——?	x		
(Endolobus) ——?	x		
Strophostylus remex (White)	x		
Naticopsis shumardi McChesney?	x		
Euomphalus subquadratus Meek and Worthen	x		
——?	x		
Murchisonia ——?	x		
Lepetopsis? ——?	x		
Bellerophon crassus Meek and Worthen	x		
Patellostium montfortianum Norw. and Pratt	x		
Bellerophon ——?	x		
Sedgwickia topekaensis (Shumard)	x		
Pleurophorus ——?	x		
Modiola subelliptica Meek	x		
Yoldia subscitula Meek and Worthen	x		
Myalina permiana Swallow	x	?	
aviculoides Meek and Hayden	x		
perattenuata Meek and Hayden	x		
Pteria longa (Geinitz)	x		
Aviculopecten occidentalis Shumard	x		
Syringopora ——?	x		
Spirorbis ——?	x		
Estheria? minuta Jones?	x		
Cythere nebrascensis Geinitz	x		

Species.	Enid-Wichita.	White-horse.	Quarter-master.
Spirorbis sp	....	r	
Serpula? sp	....	....	rr
Bryozoan, encrusting	....	rr	
ramose	....	r	rr
Dielasma schucherti Beede	....	aa	aa
Solenomya sp	....	rr	
Edmondia rotunda, n. sp	....	r	r
cumminsi, n. sp	....	....	r
Conocardium oklahomaense Beede	....	c	
Cyrtodontarca gouldii Beede	....	c–a	c–a
multidentata, n. sp	....	r	r
parallelidentata, n. sp	....	c	c
Pseudomonotis? sp	....	r	
Myalina sp	?	rr	
Schizodus ovatus Meek and Hayden?	....	c	r
oklahomaensis, n. sp	....	rr	
Aviculopecten oklahomaensis, n. sp	....	a	r–c
vanvleeti Beede	....	c	r
Allorisma? albequus, n. sp	....	r	c
Pleurophorus albequus, n. sp	....	aa	a
albequus longus, n. var	....	c	r
Pelecypod sp	....	....	rr
Pleurotomaria capertoni, n. sp	....	r–c	r–c
agnostica, n. sp	....	r–c	
sp	....	rr	
Worthenopsis depressa, n. sp	....	r	
sp	....	....	r
Trepospira haworthi, n. sp	....	c	c
Murchisonia collingsworthensis, n. sp	....	....	r
gouldii, n. sp	....	x	x
Loxonema permiana, n. sp	....	....	r
Orthonema dozierensis, n. sp	....	....	rr
texana, n. sp	....	rr	c
Bulimorpha? alvaensis, n. sp	....	rr	
Capulus?? haworthii, n. sp	....	....	r
sellardsi, n. sp	....	c–a	
Strophostylus permianus, n. sp	....	a	r–c
Naticella transversa, n. sp	....	....	r
Plagioglypta?? sp	....	....	rr

So far as known, the vertebrate fauna of the Red Beds is confined to the equivalents of the Enid formation, or nearly so. They have already been enumerated, and it is not necessary to repeat them here.

The striking differences between the Oklahoma-Panhandle fauna and that of the Wichita-Clear Fork fauna, as described by White, is brought out clearly by the table just given. However, it is to be remembered that the Wichita material is a limestone fauna, while the fauna of the upper beds is a sandstone fauna.

Another fact shown by the table is that the fossils of

American affinities represented in the Whitehorse sandstone show a decided decline in the Quartermaster beds, while the reverse is true of the foreign element, probably due to slower immigration.

DESCRIPTION OF SPECIES.

The drawings of the last two plates and text figures of this article are by Miss Maud Siebenthal, of Bloomington, Ind.

SPIRORBIS sp.

Plate VI, figure 10.

Shell minute. Only the attached surface of the two flat whorls shown on the cast of a shell. For the first half whorl the shell is nearly straight. The curve of the spiral begins abruptly. Greatest diameter a little less than a millimeter.

Whitehorse spring, Oklahoma ; rare.

SERPULA? sp.

Plate V, figure 5.

A very minute cast of a serpulid (?) worm on the internal cast of a shell. The greatest diameter of the coil is about a half millimeter.

Dozier, Tex. ; very rare.

STENOPORA sp.

A species, probably of this genus, was found at Whitehorse spring and at Dozier. Prof. A. F. Rogers writes me that it is practically impossible to identify them, stating : "I would call the one from Dozier *Stenopora* sp., and the one from Whitehorse the same." There was also an encrusting form from Whitehorse.

DIELASMA SCHUCHERTI Beede.

Plate V, figures 1-1*m*.

Dielasma schucherti Beede. Inv. Pal. Red Beds, p. 7, plate I, figs. 1-1*c*, 1902.

Shell rather small, biconvex, biplicate, subelliptical in outline, slightly tapering at the beak. The cast shows an arcuate pedicle valve, nearly equally convex except in front where it becomes somewhat flattened and contains two depressions, corresponding to the two folds in the other valve. The first indication of the fold and sinus first appears in pretty large individuals and shows the ordinary fold of a *Dielasma*, the biplicate character appearing only in well-developed individuals. Along with this development comes a peculiar change in the form of the shell. It nearly ceases to grow laterally, and the additional growth takes place largely on the anterior margin, which narrows and becomes cuneate in longitudinal section. At the time when the biplication first becomes noticeable the shell is relatively very much broader than in the adult stage. The dental lamellæ are well developed in the adult individuals. They began to appear at a somewhat earlier stage than the biplication, but are not shown until the specimens reach a length of over seven millimeters. These plates, in the cast, give the appearance of a subquadrangular foramen ; however, the foramen was nearly circular. In the brachial valve the features are similar to those of the pedicle valve, except that it is more convex and its lateral edges much more elevated. In the young specimens the muscular impressions seem to have sunken deeply into the shell itself. In larger ones the shell seems nearly plain within, while in the adult specimens there seems to be a cast of a true platform characteristic of the *Dielasmas*. The crural lamellæ are not very strikingly developed, though present. No specimens with the loop preserved have been seen in the fossils from Oklahoma. Two specimens from Texas show the loop very well, as shown on plate V. One of these is somewhat smaller than the other, and the loop is not yet united ; in the larger one it is complete. These specimens are not over half grown. The adult form would doubtless show some further modifications.

Whitehorse spring, Oklahoma ; very abundant. Dozier, Tex. ; very abundant.

There is a large valve in the Oklahoma collection showing four plications instead of two. This is probably a pathologic specimen, or may represent another species. The tendency to produce abnormalities in this fauna is rather marked.

The surface of specimens of this species seems to have been smooth except for occasional growth marks. The shell was punctate, as is clearly shown in a specimen with a portion of the shell preserved in the mold. The proportion of young specimens to fully developed adults is about 80 : 1, probably due to unfavorable environment.

SOLENOMYA sp.

Plate V, figure 4.

The cast of a small *Solenomya* of a comparatively low, long form. The details of the surface ornamentation and the end of the specimen are not preserved on the specimen figured. What appears to be the long end of another individual has the shorter end gone, so it is impossible to identify it specifically. However, I have seen no other species identical in form with it. Greatest length, 11 mm ; height, 4 mm.

Whitehorse spring, Oklahoma ; very rare.

This species has much the form of *S. biarmica* de Vern., of Great Britain, but the ridge in the shell in the umbo curves more sharply to the rear (short end) as shown in our casts. They show what are probably the traces of fine radiating lines in the shell, though they are hardly distinct enough to be reliable.

EDMONDIA ROTUNDA, n. sp

Plate VII, figures 3-3*b*.

Shell ovate, approaching semicircular outline, gibbous. Beak gibbous, elevated, subcentrally located. The entire shell is quite convex. Margins regularly rounded at both extremities and rounding up to the nearly straight hinge. Surface ribs impressed on the cast. Excavation formed by the platform beneath the beaks plainly visible. Length, 6.25 mm. ; length of hinge, 4 mm. ; distance from beak to front, 2.5 mm. ; height, 4 mm.

Whitehorse spring, Oklahoma ; rare. Dozier, Tex. ; rare.

This species may be distinguished from *E. cumminsi*, *postea*, by its more rounded outline, greater convexity, and more centrally located beak. This species is probably closely related to *E. semiorbiculata* Swallow, from near Council Grove, Kan., but, judging from his description, is much smaller and beaks are more prominent.

EDMONDIA CUMMINSI, n. sp.

Plate VII, figures 4, 4*a*.

Shell small, transversely elliptical, rather compressed laterally. Relation of height (hinge to ventrum) to the length is about 7½ to 9 mm. Hinge comparatively straight, about three-fourths as long as the shell, rounding into the anterior and posterior outlines on either end, more rapidly on the anterior. Beaks only moderately prominent, situated a little in front of the middle, incurving forwards. Valves only moderately convex. The cast of the platform beneath the beak is well developed in the type specimen. The cast has only extremely faint traces of the surface undulations impressed on the umbonal ridge.

Dozier, Tex.; rare.

This species differs from *E. rotunda*, *ante*, in the length of the hinge, less convexity of the valves, and somewhat more appressed beak.

CONOCARDIUM OKLAHOMAENSE Beede.

Plate VII, figures, 2-2*f*.

Conocardium oklahomaensis Beede. Inv. Pal. Red Beds, p. 6, pl. I, figs. 3–3*c*, 1902.

Shell attaining moderate size, thick, and typically conocardiiform. Anterior and posterior lengths of the shell about equal, posterior abruptly truncated and then tapering to the point of a long tube. The beaks are centrally located, the carina very strong, angular, and oblique. The anterior portion tapers gradually to the end of the shell, where it turns somewhat downward and is abrubtly cut off. The posterior ventral outline is decidedly sinuate. The surface of the anterior part of the shell is marked by very coarse radiating costæ, eight or ten, in an adult individual, and about a half-dozen coarse concentric ridges, producing a very rough, cancellated appearance. The region of the carina is covered with very fine concentric laminæ, and the posterior side of it by nearly equally fine radiating lines producing a fine cancellation. There are also four to six radiating ribs on the posterior side of the carina. Length, 17+ mm.; height, 7 mm.

Whitehorse spring, Oklahoma; common.

The only other *Conocardium* that I know of occurring in the Permian is found in the valley of Palermo, and belongs to a decidedly older horizon. It is a very different form from ours.

CYRTODONTARCA Jak.

So far as observed, our fossils from the Red Beds do not have the vertical cartilage pits on the area, as figured by King for *Bakewellia*, and, instead, seem to show only horizontal striations. The dentition seems to be somewhat similar in both genera. Our specimens are referred to *Cyrtodontarca*.

CYRTODONTARCA ? GOULDII Beede.

Plate VI, figures 1–1e.

Bakewellia gouldii Beede. Inv. Pal. Red Beds, p. 5, pl. I, figs. 2–2c, 1902.

Shell of moderate size, aviculiform, compressed, thin, considerably longer than the hinge. Beaks low, subterminal; umbonal ridge well defined. Anterior ear nearly obsolete; posterior one alate, not sharply separated from the body of the shell. Border sinus very shallow, anterior margin rather sharply and regularly rounded, ventral margin gently curved posteriorly and nearly straight in front, rounding abruptly to the end of the hinge. There is rarely any indication of a sinus in the adult left valve, though slight ones are sometimes seen in the younger specimens. There is usually a slight depression extending from the front of the beak a little obliquely backward nearly to the margin of the shell. The hinge of the left valve is armed behind with one lamellar tooth which is nearly parallel to it, and the anterior part with a rather complex dentition. There are two diagonal teeth beneath the beak, lying about parallel with the axis of the umbonal ridge; in front of these is a third tooth, curved forward and enlarged to twice or three times the size of the others. Connecting with the lower end of this enlargement there is a ridge extending as a buttress downward behind what appears to be a semiobsolete muscular impression, somewhat as in the *Pleurophori*, though much less marked. Sometimes there seems to be a very slight, thin tooth in front of this scar. There is a strong muscular impression in front of the beak to the rear of the buttress. This scar, as will be noted later, is prominent on some of the shells of this group.

So far as can be seen from our casts, the posterior adductor scar is large, and situated just above the umbonal ridge, opposite the extremity of the posterior tooth.

The form of the right valve differs from that of the left only in usually possessing a slight sinus in the ventral margin beneath the beak. The posterior end of the hinge is armed with two horizontal teeth instead of one. The anterior dentition is such as to correspond with the other valve. The surface of the shell seems to be marked with lamellar growth lines, arranged closely along the hinge and more remotely on the other parts. Length of hinge, 5.5 mm.; length of shell, 9.5 mm.; height at posterior end of shell, 5 mm.

Whitehorse spring, Oklahoma; common to abundant. Dozier, Tex.; common to abundant.

In some of the right valves of this species the buttress seems to be disconnected from the third tooth.

CYRTODONTARCA ? MUNTIDENTATA, n. sp.

Plate VI, figures 4, *4a*.

Shell practically equivalvular, left may be a trifle the more convex, the form similar to the preceding species. There is a very slight sinus beneath the beak. The hinge has five teeth in the anterior end of the right valve and six in the left, with vertical buttress in addition. The posterior end of the hinge is furnished with two horizontal teeth to each valve. It may be, however, that the upper impression shown in the cast is a ligamental impression. The upper one is the more prominent of the two, the lower being more remote from the beak and smaller, and appearing only on the maturity of the shell. Length of hinge, 6 mm.; length of specimen, 10 mm.; height at posterior end, 5 mm.

Whitehorse spring, Oklahoma; rare. Dozier, Tex.; rare.

CYRTODONTARCA ? PARALLELIDENTATA n. sp.

Plate VI, figures 3-3*c*.

This species is more closely related to *Bakewellia parva* Meek, than any other species of the Whitehorse beds. It has a much closer relative, however, in an undescribed species from the lower Permian of Kansas, though the characters of the muscular scars at once distinguish it. In form this species resembles the rest of the Red Beds species. Its distinguishing characters are two subparallel teeth on the anterior end of the hinge, the lower of which may be connected with the buttress. Posterior adductor large. Length of hinge, 5 mm.; length of specimen, 7.5 mm.; height at posterior end, 4.5 mm.

Whitehorse spring, Oklahoma; common. Dozier, Tex.; common.

The average umbonal angle seems to be larger and the shell somewhat broader with respect to the hinge than in the other species.

It should be remarked here that the forms of these species are not sufficiently well preserved to distinguish between them with certainty. It is very probable that with well-preserved material, showing all the critical features of each species, they might be readily separated. As it is, a specimen showing the outline or surface features does not have the teeth preserved, and *vice versa*.

PSEUDOMONOTIS Beyrich.

Hind [50] splits the genus *Pseudomonotis* into two genera, separating *P. hawni* Meek from *P. speluncaria* Schlotheim. His grounds for doing so are: "This species [*P. speluncaria*], however, has a peculiar posterior lobe separated from the rest of the valve by an oblique sinus; the left umbo is arched to a greater extent, and the hinge-line not so pronounced as in *Eumicrotis*." With these remarks the question is dismissed, and *Eumicrotis* of Meek is given to those shells without the sinus and lobe, while the others are apparently left with *Pseudomonotis* and regarded as Permian. This may hold for European specimens of this group, but it is very difficult of application in this country. Meek's discussion of the type species of his proposed genus *Eumicrotus*, which he afterward conceded to be synonymous with *Pseudomonotis*, will not be out of place here. It is as follows: [51]

50. Brit. Carb. Lam., II, pt. 2, pp. 41-44, 1903.

51. Pal. Upp. Mo., p. 55, 1864.

"In first describing this species, we called attention to its close relations to *E. speluncaria* Schlot. (sp.), and stated that we were aware it would not be easy always to find characteristic differences by which certain varieties of these two forms could be distingushed. Every naturalist, however, must have met with analogous cases, where the varieties of two closely allied but variable species approximate, and, as it were, mingle together, so as to render it sometimes extremely difficult to separate them; while the normal forms of each are so clearly distinct as to leave no doubt on the mind that they belong to different species. This, we think, is the relation the Kansas shells bear to *E. speluncaria*, although we are aware some of our friends entertain the opinion that they are not distinct.

"It is true some specimens agree almost exactly with such varieties of *E. speluncaria* as are represented by figures 15, 17, 20, and 21, plate XIII, of King's work on the Permian fossils of England; yet, out of hundreds of individuals collected and seen by us in Kansas, we have never met with one presenting the peculiar lobed and sulcated posterior so characteristic of the well-developed normal forms of *E. speluncaria*, such, for instance, as figures 5, 6, 7, 8, 9, 10 and 11 of plate XIII of King's work cited above. Again, none of our Kansas specimens, with a solitary exception, has had the beak of the right valve so gibbous, or near so elevated, as those represented by the figures last above cited; and in this single exception the shell differs so widely in other respects that, if not a monstrosity, we can but regard it as belonging to a distinct species from that under consideration, as well as from *E. speluncaria*."

While differences of opinion as to the limits of definition of the species of the genus exist, most all will agree that it is an unusually variable one. I have quoted Waagen on this point already,[52] and agree very well with his conclusions.

In the Pennsylvanian and Permian of Kansas there are many of these fossils which possess the lobation of the shell to a varying degree. While I have studied many from the oölite of Kansas City and the Kickapoo limestone at Lawrence, and

52. Kan. Univ. Quart., III, p. 79, 1899. From Pal. Ind. Prod. Limestone Foss., III, p. 276.

the Permian rocks as well, where they occur in abundance, I hardly think I ever saw two of them with the same degree of lobation. It is true, however, that none of them possess such large lobes as those referred to by Meek and separated from *Eumicrotis* by Hind. Nevertheless the lobation exists, even in the type species of *Eumicrotis*, to some considerable extent among many individuals. To separate these out would be to split a single species into two genera. However, it should be remarked that the beaks are not so inflated and drawn out as in some specimens of *P. speluncaria* as figured by King. Neither are they so incurved over the hinge. But this feature also is an extremely variable one in our American species, and of itself is hardly of generic value. In the light of these facts it seems to me advisable to retain the term *Pseudomonotis* for the American fossils usually grouped under that term. Furthermore, I believe that they are sufficiently divided into species and varieties, with perhaps one exception, so far as they are known to me.

PSEUDOMONOTIS? sp.

Plate VII, figure 1.

Fragments of two flat valves, with very peculiar markings. The outline of the lower portion of the shell is nearly circular; the upper part unknown. The ribs are small and slender, flexuous, and made nodose by vaulted scales. They are spaced four times their diameter apart. There is occasionally a faint trace of an intermediate striation seen in the bottom of the broad, flat furrows. The whole area is crowded with fine, imbricating growth marks or concentric striæ. The length of the larger fragment is 24 mm.

Whitehorse spring, Oklahoma; rare.

The flexuous, nodular striæ remind one of *Pseudomonotis*, but it may belong to some other genus.

MYALINA sp

Plate VI, figure 7.

Shell rather small, quite elongate; beak apparently pointed. This specimen, the only one in the collection, has the beak broken away. The angle between the hinge and the front margin is about 38 or 40 degrees. The specimen is too fragmentary for specific determination. Length of specimen from point of broken beak, 17 mm.

Whitehorse spring, Oklahoma; very rare.

This shell seems to be closely related to *M. permiana* and *M. cuneiformis* Girty, so far as general form goes. It may be identical with the latter, but I think it is not.

SCHIZODUS OVATUS Meek?.

Plate VII, figures 7, 7*b*.

Shell of moderate size; not very convex; hinge rather short; beaks prominent; umbonal ridge well defined, subangular; relation of height to length in perfect specimens probably a little less than three to five. Anterior outline from beak downward ovate; ventral border elliptical; postero-ventral border semitruncate, posterior nearly straight. The beaks are incurved. Some of these specimens show traces of concentric undulations. Three specimens. Height, 18, 14, 18 mm.; length, 26, 19, 23.5 mm., respectively.

Whitehorse spring, Oklahoma; common. Dozier, Tex.; rare.

The *Schizodus* material in these collections is unsatisfactory. In the previous paper there were two species represented. However, they were destroyed in the fire at University of Oklahoma, and good material is wanted in our collections, except for immature specimens, which are not satisfactory in critical work.

SCHIZODUS? OKLAHOMAENSIS, n. sp.

Plate VII, figure 6.

Shell rather small and schizodiform. Beak very prominent, highly elevated, rather sharp, nearly vertical, almost centrally located, and curving inward. The hinge is comparatively short, so far as shown in the specimen. Posterior umbonal ridge very prominent. The anterior margin slopes obliquely downward from the beak, and rounding sharply into the elliptically curved ventral margin. Postero-ventrally the margin curves abruptly upward at the foot of the umbonal ridge, making the lower posterior border truncate, the upper portion bending to the hinge at an obtuse angle. The convex portion of the shell is marked with heavy undulations, in a manner approaching some of the Mesozoic members of the family. Length, 12 mm.; height, 8 mm.; beak, 5.5 mm. from front.

Whitehorse spring, Oklahoma; very rare.

This may not be a *Schizodus*, but the hinge is so poorly preserved that none of its characters are shown. It seems to resemble *Schizodus* as much as anything else, and is provisionally referred to it.

AVICULOPECTEN OKLAHOMAENSIS, n. sp.

Plate V, figures 3-3c; plate VI, figures 11-11c.

Shell like *A. occidentalis* in most of its features, and may be but a variety of it. The hinge is nearly equal to the length of the shell. The beak projects above the hinge, is acute, and in many spcimens is inflated, erect, or slightly inclined forward. Anterior ear well defined, convex, rounded at the extremity, separated from the umbo by an angular depression and is marked by about nine coarse radiating striæ or costæ and covered with close-vaulted scales. Little can be made out of the posterior ear of the left valve, except its general form, which is quite angular. It is separated from the shell by a rounded furrow. The posterior ear appears to be about as long as the anterior, and nearly smooth except for concentric lamellar markings. The surface is marked by two- or three-ranked costæ, according to their age, the later ones being smaller and implanted between the larger ones. They are straight or somewhat flexuous, flattened, and separated by furrows of about their own width. These are crossed by rather coarse lamellæ which may be rather distant or crowded, depending on the rate of growth of the individual at any point. These lamellæ are coarser than those of *A. occidentalis.* Right valve, probably belonging to this species, nearly flat, beak not elevated, outline and ears much as in the left valve, except the anterior ear, which is deeply cut by the byssal notch. Both ears show faint radiating costæ and concentric marks. Body of the valve nearly smooth, with but trace of radiating costæ.

Whitehorse spring, Oklahoma; abundant. Dozier, Tex.; rare to common.

The only distinctions between this species and *A. occidentalis* Shumard are the (frequently) smaller angle of the beak, which is a little more projecting, the extreme scaly appearance of the anterior ear, and the more pronounced character of the concentric lamellæ of the body of the shell. In old specimens some of the costæ become somewhat enlarged, as in *A. vanvleeti*, but there is little danger of confusing it with that species.

AVICULOPECTEN VANVLEETI BEEDE.

Plate V, figures 2–2e.

Aviculopecten vanvleeti BEEDE, Inv. Fauna Red Beds, p. 6, pl. I, fig. 8, 1902.

Shell large, of variable form. Ears well developed, distinct and prominent. The outline of the shell is much the same as in *A. maccoyi*, and the surface marks are similar in most respects. The beaks are prominent and elevated above the hinge, gibbous. Hinge nearly straight, about three-fourths the length of the shell; anterior ear convex, separated from the umbo by a deep sulcus, and the anterior margin is deeply sinuate on its lower side. Posterior ear nearly flat, about as long as the anterior one, separated from the umbo by a less distinct sulcus, and the posterior margin is made gently sinuate by it. The surface is marked by two-ranked radiating costæ. Three to six of these are much larger, and appear to be nodular in the cast, probably caused by vaulted lamellæ. Between each of these are six to fifteen smaller, rather sinuous, striæ, which increase by implantation, and are rounded, low, separated by interspaces equal to their width, and crossed by concentric lamellar markings and larger varices of growth. The larger costæ do not become well developed until 15 or 20 mm. from the point of the beak, though they are usually traceable nearly to the point. No specimen before me possesses both ears, but one specimen possesses a posterior ear with five longitudinal striæ, while another individual shows eight or ten ribs bending downward on the anterior ear.

Whitehorse spring, Oklahoma; common. Dozier, Tex.; rare.

This species can be distinguished from *A. maccoyi* Meek and Hayden, by its larger size and especially the larger striæ, which are not strikingly prominent until 15 or 20 mm. from the beak, while those of *A. maccoyi* Meek and Hayden, are equally distinct 3 to 5 mm. from the beak. Otherwise they are very similar. The general appearance of the shell is a trifle like *A. occidentalis* Meek, but is at once distinguished from it by its larger ears with coarse marks and the nodose character of the larger ribs.

ALLORISMA ? ALBEQUUS, n. sp.

Plate VII, figures 5-5c.

Shell minute, equivalvular, subquadrilateral, beaks prominent. The anterior margin descends obliquely from the beak to the anteroventral region where it is abruptly rounded. Ventral margin is slightly sinuate because of the faint depression extending obliquely backward and downward from the beak. Posterior margin pretty regularly rounded, meeting the hinge at a very oblique angle. Hinge straight, its other characters unknown. The beaks project above the hinge and are incurved forward. The surface was probably nearly smooth, with faint undulations of growth. Two specimens: Length, 5.5 mm., 4.5 mm.; height, 2.25 mm., 2 mm., respectively. Length of hinge, 2.75 mm. and 2 mm

Whitehorse spring, Oklahoma; rare. Dozier, Tex.; common.

These fossils have the general expression of the *Allorismas*, and are provisionally referred to them until material demonstrating the character of the hinge dentition can be had.

PLEUROPHORUS? ALBEQUUS, n. sp.

Plate VI, figures 8-8e.

Pleurophorus sp. BEEDE, Inv. Pal. Red Beds, p. 9, pl. I, fig. 4, 1902.

Shell of medium size to rather small for this genus; height at the beak about one-third the length; beak rather prominent, nearly terminally located, projecting above the hinge; umbonal ridge not sharply defined, but well rounded; in front of the ridge is an undefined oblique depression, frequently producing a slight sinuosity in the ventral margin. Hinge very slightly arcuate and long. The anterior outline slopes and rounds obliquely downward, merging into the ventral margin, which may be nearly straight and nearly parallel to the hinge or a little sinuate. Posterior extremity rounded and meeting the hinge at a very obtuse angle. Valves about equally convex. The semielliptical adductor scars are very deeply impressed, with the strong ridge of shell behind fading out toward the base of the shell. The pedal scar, situated above and back of the adductor, is very small. Cardinal teeth two, one nearly parallel to the hinge, while the other rests more obliquely over the adductor impression. A faint line indicates a slight forking of the upper tooth in some casts. The posterior teeth are shown in the casts as being nearly parallel to the hinge, but diverging downward from it at a slight angle. The tooth on the left valve is more strongly developed than the one on the right, the latter not being preserved in the great majority of casts. The matrix is coarse material and poorly adapted to preserving the finer marks or ridges. The surface is marked by growth lines which are strongest on the anterior part of the shell, two to five or six faint radiating lines extending from the beak to the posterior end of the shell and "granulations" on the depression below the beak. The ligament is external, situated in grooves. Length, 14 mm.; height, 5.5 mm.

Whitehorse spring, Oklahoma; very abundant. Dozier, Tex.; common.

This species differs from *P. occidentalis* Meek and Hayden in being larger, having an arcuate hinge, and in having the pedal scar farther back, judging from his description. It differs from *P. oblongus* Meek in being proportionally much longer and in possessing radiating ridges. Compared with *P. subcuneatus* Meek and Hayden, our species has the ridge of shell back of the adductor scar extending somewhat backward rather than vertical, as well as much narrower and more sharply defined. The umbonal ridge is more poorly defined on our specimens, which also show two to six radiating ridges. There also appears to be some difference in the dentition.

Our species seems to be closely related in general appearance, at least, with *P. meeki* Walcott, but does not widen very distinctly posteriorly, and the beak appears to be situated farther back.

These shells differ from the known *Pleurophori* in the possession of *Allorisma*-like "granulations" below the beak, which seem to be accompanied by the vaulting at this place of the lamellæ of growth. The granulations are roughly arranged in radiating rows. This shell has, so far as may be determined from the material at hand, the external characters of *Pleurophorella* Girty. However, he allies that genus with *Allorisma*, as a probable subgenus. Our specimens are certainly closely similar to *Pleurophorus* in dentition, muscular markings, and form. If Girty's genus is closely related to *Allorisma*, as he thinks it is, we cannot refer our specimens to it. If parallel development is to be looked for among the pelecypods, where it seems to me to be very likely to occur, external features are of little value as generic criteria when the critical characters are unknown. At any rate, the Dozier and Whitehorse specimens cannot be referred, even provisionally, to *Pleurophorella* until Doctor Girty determines whether it belongs in the order *Anomalodesmacea* or the order *Teleodesmacea.*

Our specimens differ from the *Pleurophori* only in the possession of granulations on the region beneath the beak and perhaps a reduction of the upper cardinal tooth.

PLEUROPHORUS ALBEQUUS LONGUS, n. var.

Plate VI, figure 9.

More than three times as long as high, hinge usually straight, umbonal ridge very faint. Dentition as in the preceding species. Some of the valves show angulation on the posterior end just below the hinge line. No definite radiating ridges seen on adult specimens, though they may be present, as the larger the specimen the more poorly it is preserved in these rocks. The depression beneath the beak appears to be missing and the ridge back of the adductor impression is nearly vertical. Otherwise as in the species. Two specimens: Length, 27 mm, 13 mm.; height, 7 mm, 4 mm., respectively.

Whitehorse spring, Oklahoma; common. Dozier, Tex.; rare.

PELECYPOD, sp.

Shell small, subelliptical; beak moderately prominent, projecting, located more than a third the distance from the anterior to the posterior end of the shell. Hinge straight or very slightly arcuate, much shorter than the shell No indications of cardinal characters visible. The margin in front of the beaks slopes obliquely to the end of the shell, where it rounds off in an elliptical curve to the base, which is nearly straight, but somewhat convex. It rounds in an elliptical curve to the hinge, which it meets at a very obtuse angle. The entire valve is moderately convex, most convex on the umbo. Surface marks unknown. Length, 6 mm.; height, 3.5 mm.

Dozier, Tex.; very rare.

The generic as well as the specific characters of this shell are not sufficiently shown to make an attempt at identification worth while.

PLEUROTOMARIA CAPERTONI, n. sp.

Plate VIII, figures 9–9c.

Shell small, robust; whorls five, quite convex, rapidly enlarging, sutures deeply impressed. Below the suture and above the band there are three, occasionally but two, revolving lines, the lowermost of which is the largest. The keel is large and rounded, with a moderately narrow concave band below it. The band has a minute, thread-like revolving line in the center. The lower side of the band is bordered by a ridge smaller than the upper one. There are six revolving lines on the body whorl below this ridge. One of these appears on the spire between the band and the suture. The mold shows crowded, sharp growth lines transverse to the whorls, which appear to arch backward on crossing the band. Apical angle, 45–50 degrees.

Dozier, Tex.; Whitehorse spring, Oklahoma.

This species is closely related to *Worthenopsis kschertianæ-*

formis Jakowlew, but differs in having more ventricose and less angular whorls, sometimes three lines on the spire above the carina and a smaller apical angle. It is strikingly similar to *Turbo helicinus* (Schlotheim), from the British Permian. Inasmuch as the presence of the slit has not been determined with certainty in the specimen at hand, it is possible that they are very closely related.

PLEUROTOMARIA AGNOSTICA, n. sp.

Plate VIII, figures 13*a*, *b*.

Shell small, spire elevated, whorls five or six, suture distinct, slit high and rather deep, placed on the upper angle of the whorl, umbilicus open and small. The upper surface of the whorls is somewhat convex in the casts. The edge of this flattened region is quite obtusely angular, below which the shell is rounded to the lower third of the whorl, where it curves sharply into the base. Shell ornamented by several revolving striæ on the upper two-thirds of the whorl. The casts show no marks on the lower third of the body whorl. The shell is thick at the keel, and on the upper whorls about four strong revolving lines may be distinguished in the edge of one mold. There are faint indications on the cast of one or two broad lines above the keel. No transverse markings are shown on the specimens before me. Height of spire about 7 mm.; of body whorl, 2½ mm.; diameter of body whorl, 4½ mm.

Whitehorse spring, Oklahoma; rare to common.

This species is related to *P. humerosus* Meek, but is a more slender species with a stronger keel. It would also seem to be related to *P. proutana* Shumard, but the carination is above the middle. It differs from *P. perornata* Shumard in not having strong transverse markings.

WORTHENOPSIS? DEPRESSA, n. sp.

Plate VIII, figures 4, 4*a*.

Pleurotomaria sp. Beede, Inv. Pal. Red Beds, p. 7, pl. I, figs. 13, 13*b*, 1902.

Shell of moderate size, spire quite depressed. There are three of four vertically compressed whorls. The body whorl expands rapidly, nearly flat on top, the outer edge keeled and angular, the angle being somewhat larger than a right angle;

the outer portion of the whorl is nearly vertical or a little concave, rounding off into the convex lower side. The suture is well defined, so far as may be determined from the cast. The umbilicus is rather wide, but from our specimens it cannot be told whether it was closed or open. A cross-section of the body whorl is subquadrate. The surface of the shell was ornamented with six or seven revolving striæ on the upper side of the body volution, eight or nine around the periphery, and probably a larger number of finer, more crowded ones on the lower side. No indications of transverse striæ or growth marks are shown on our casts, though doubtless the shell had fine lines of this character. Height, 6 mm.; width, 9.5 mm.; height of body whorl, 4 mm.

Whitehorse spring, Oklahoma; rare.

This species would seem to be very distantly related to *Pleurotomaria linkiana* King, from the English Permian, so far as form and surface features are concerned. Our species has a more depressed spire and is more angular than that species. It is much more closely related to *Worthenopsis dejactinensis* Jakowlew, from Russia.

WORTHENOPSIS sp.

Plate VIII, figure 13.

Shell very small, whorls five or more, sutures deep. The whorls are compressed vertically, sharply angular, and bicarinate, a single carina showing on each whorl of the spire about two-thirds the distance from the upper to the lower suture. The whorls are vertically compressed, sharply angular, with a concave band. The top of each succeeding whorl is wound along the middle of the band, concealing the carina on the lower side. On the body whorl the carina below the band is less prominent than the one above it and is less distant from the axis of the shell. Other characters unknown. Height, 2 mm.; width about 1.5 mm.

Dozier, Tex.; rare.

This species may be distinguished at once by the angularity of its whorls and the fact that only the upper keel shows on the spire.

TREPOSPIRA HAWORTHI, n. sp.

Plate VIII, figures 3-3*b*.

Shell small, spire turreted, whorls enlarging rapidly, keeled, and sharply angular. The upper part of the whorls are obliquely flattened for a short distance to the edge of the keel where they bend abruptly downward and round off below. There is somewhat of a callosity in the region of the umbilicus. There are about four whorls in the adult shell. The surface is ornamented with about eighteen fine revolving striæ, five of which appear above the carina and about thirteen below it. Near the umbilicus these lines are quite fine. About two or three of the lines below the carina are visible on the upper whorls of the shell. The suture is very distinct. Some Texas specimens show fine, elevated, crowded, transverse striæ. The height of a complete specimen would be about 3 mm.; width, $2\frac{1}{2}$ mm.; height of lower whorl, 2 mm.

Whitehorse spring, Oklahoma; common. Dozier, Tex.; common.

This species is related to *P. humerosa* Meek, but the much smaller size ($\frac{1}{5}$) and greater number of revolving striæ will at once distinguish them. Judging from our casts the shoulders of the Red Beds specimens must have been quite as prominent as those on the Pennsylvanian species just mentioned. It also resembles *Trepospira dives-ouralica* Jakowlew, from Russia, but has a much higher spire and is a very much smaller species.

MURCHISONIA COLLINGSWORTHENSIS, n. sp.

Plate VIII, figures 7, 7*a*.

Shell of moderate size, acute; suture impressed; whorls enlarging very gradually; keeled; umbilicated below. The whorls are beveled slightly outward from the suture, thence falling nearly downward with a slight concavity (shown in the best squeezes), producing a low, undefined ring, scarcely perceptible, just below the suture. A little over half the distance to the suture below is a prominent, rounded keel. The lower side of this keel is somewhat concave nearly to the suture below, where about half the ridge below the keel shows above the suture. On the body volution the keel is located just a trifle above the middle, followed by a second, much fainter one, below it. The two are separated by a concavity. The base rounds off rapidly below the keel. The nature of the apertural region is unknown. The surface is marked, as shown in the mold, by slightly flexuous growth lines bending backward on the keel. Apical angle about 42 degrees.

Dozier, Tex.; rare.

This species differs from *M. texana* in having a larger apical angle, the band higher above the suture, more prominent, and sharper. It differs from *M. golowkinskii* Jakowlew in having a larger angle of divergence (42 degrees instead of 28 degrees), and possibly some details of the body whorl.

MURCHISONIA GOULDII, n. sp.

Plate VIII, figures 6-6*b*.

Shell small, narrowly trochiform; whorls about seven, keeled, regularly expanding, angular; sutures distinct. There are three revolving ridges on the shell, the upper bordering the suture, the middle one forming the prominent keel in the middle of the volution, and a lower one covered by the upper one in the spire, a short distance below the keel. The interspaces are concave. The upper ridge makes the suture canaliculate. On the body whorl the shell strikes suddenly off below the lower ridge, leaving the base of the body whorl nearly flat. The surface is marked on the band and above it by fine revolving lines. None have been seen below.

Whitehorse spring, Okla.; Dozier, Tex.

This species may be distinguished from *M. collingsworthensis*, *ante*, by the fine revolving lines on the band and above it.

LOXONEMA PERMIANA, n. sp.

Plate VIII, figures 14, 14*a*.

Shell minute, acutely pointed, very slender, the suture distinct. There are probably eight or ten whorls in an adult specimen, enlarging very slightly, with moderately deep sutures. The distance from suture to suture on the lower portion of the spire is about equal to the diameter of the shell at that place. Apex of the spire and base of the body whorl unknown. Surface apparently without ornamentation.

Dozier, Tex.; rare.

This species differs from *L. peoriensis* Worthen in having more convex whorls and deeper suture.

ORTHONEMA DOZIERENSIS, n. sp.

Plate VIII, figure 8.

Shell small, plane, enlarging very slowly; suture narrow, impressed. The spire of this shell seems to be entirely plane except for the impression of the linear suture. The base of the body whorl is angular, sloping rather abruptly inward. Below this angulation there is a revolving ridge.

Dozier, Tex.; very rare.

This species resembles *O. texana* in general appearance, but has no ring at the suture. It differs from *O. salteri* M. & W. in being more slender and devoid of revolving lines on the spire. It differs in this respect from *O. carbonarium* of Worthen. It is more closely related to *O. conica* M. & W., but is a more robust and less acute shell.

ORTHONEMA? TEXANA, n. sp.

Plate VIII, figures 5, 5*a*.

Shell of fair size, spire trochiform and acute, whorls eight or ten, enlarging very gradually. Suture distinct and impressed. Below the suture, in the spire, the shell is beveled outward for a short distance, whence it turns downward with a concave outline, forming a slight ring below the suture. The middle of the whorl is slightly concave, ending in a sharply rounded elevation immediately above the next suture. On the body whorl, below the carina just mentioned, there is a second but smaller ridge, followed by a third, which is still weaker; below this there is a relatively broad, slightly concave area and a fourth angular ridge, followed by one or two indistinct lines surrounding the umbilical region. Below the two larger carinæ the shell falls off very abruptly. The only transverse marks visible on the squeeze or mold are very faint indications of fine growth lines. 4.5 mm. × 10.5 mm. Apical angle about 33 degrees.

Dozier, Tex.; common. Whitehorse spring, Oklahoma; rare.

This species resembles two species from the Illinois Pennsylvanian, *O. carbinarium* Worthen and *O. salteri* Meek and Worthen. It may be distinguished from either species readily enough by its having a heavy revolving ridge just above the suture, and a very faint one below it. The relative depth of the whorl is also less.

So far as general appearances go it could be compared with *Turritella excavata* Laube, from the Triassic, from which it differs in having twice the apical angle and in having the prominent ridge above the suture rather than below it.

BULIMORPHA? ALVAENSIS, n. sp.

Plate VIII, figure 11.

Shell of moderate size, rather high, sutures distinct. Height of body whorl, 8 mm., next succeeding, $3\frac{1}{2}$ mm., and the third, $2\frac{1}{2}$ mm. The apical angle as shown in the cast is about 38 degrees. The probable number of whorls is about six. The aperture appears to be semipyriform. Diameter of the base, 6 mm. There is somewhat of a shoulder beneath the suture, below which the shell is nearly flat, until the lower portion of the whorl is reached, where it rounds off quite rapidly. The specimen is somewhat compressed in a plane parallel with the axis of the shell.

Whitehorse spring, Oklahoma; very rare.

This species seems to be related to some of the species *Bulimorpha* or *Machrocheilus* from the Kansas Pennsylvanian, but is specifically identical with none of them, so far as the characters are exhibited in the cast at hand. The generic reference is provisional.

CAPULUS? HAWORTHI, n. sp.

Plate VIII, figures 12-12*b*.

A small shell, the casts of which show no indisputable surface or muscular markings. It probably belongs to this or some gastropod genus, as *Acmæa*. They are obliquely conical, and the bases are pretty regularly elliptical. The height is about 3 mm., length about 5 mm., with the apex 3 mm. from one end.

Dozier, Tex.; rare.

CAPULUS SELLARDSI, n. sp.

Plate VII, figures 8-8*f*.

Shell of moderate size, regular in outline, with pointed beak. The beak is little elevated, has about half a turn, is acute, and twisted somewhat to the right. Aperture longitudinally ovate, edges regular, right side somewhat more excavated than the left near the beak. Surface beautifully ornamented with two sets of thread-like lines, the concentric being more distantly spaced near the beak. On the right lateral margin the radiating striæ become much larger and more distantly spaced and somewhat wavy. On the remainder of the shell the concentric lines are heavier. They are not imbricated in the region of the beak. They are minutely wavy on the front of the shell of some individuals.

Whitehorse spring, Oklahoma; common to abundant.

STROPHOSTYLUS PERMIANUS, n. sp.

Plate VIII, figures 2-2c.

Naticopsis sp. BEEDE, Inv. Pal. Red Beds, p. 7, pl. 1, fig. 12, 1902.

Shell moderately small, about three or four whorls visible on the costa, showing, so far as observed, no tendency to straighten out with age, as does *S. remex* (White). The surface is marked with transverse lines of growth which are unusually large for this genus and are pretty regularly spaced. They are not very much stronger near the suture than on the body of the whorl. Aperture elliptical. The columella seems to be present, but its nature cannot be determined with certainty. "Height of spire, 7 mm.; greatest diameter, 9 mm.; height of body whorl, 6 mm."

Whitehorse spring, Oklahoma; abundant. Dozier, Tex.; rare to common.

The shells of the Dozier specimens are somewhat smaller than those from Whitehorse spring. The growth lines are strong and sinuous, bending somewhat backward.

This species is most closely related to *S. remex* (White), but differs from it, apparently, in possessing no traces of revolving striæ, in having the body volution more closely coiled, and in attaining only half its size.

NATICELLA TRANSVERSA, n. sp.

Plate VIII, figures 1, 1*a*.

Shell small, spire low, whorls about three, rapidly enlarging. The spire is much appressed, rising but slightly. The upper whorls form but a small fraction of the height of the shell. The suture is strongly impressed, and just beneath it the shell is nearly flat and smooth for a very short distance, when it turns down abruptly with an angulation, below which the entire shell is ornamented with transverse ribs very equally spaced. They are about their own width apart, slightly keel-shaped, with rounded valleys between. Height of shell and greatest diameter about equal, 4 mm.

Dozier, Tex.; rare.

This species has a superficial resemblance to *Naticella costata* (Munst.), from the Triassic of St. Cassian, on the one hand and remotely to a species from the Kansas Pennsylvanian on the other. The generic reference is provisional. It also has a very strong resemblance to *Narica lyrata* (Phill.), from Belgium and England, but is a very different species. Attention should also be called to its resemblance to *Littorina biserialis* Phillips, as figured and described by Murchison, de Verneuil and Keyserling from the Urals of Russia. It differs very sharply from these shells in the relative height and form of the body whorl. It is to be remembered that our specimen only shows superficial characters, and that there is a great stratigraphic interval between the horizon of the European and American shells.

PLAGIOGLYPTA?? sp.

Shell minute, shaped like *Dentalium* and allied shells. The diameter at the larger end is about $\frac{2}{3}$ mm. It was ornamented with comparatively coarse annulations. The specimen is too fragmentary to admit of specific determination or correct generic reference.

Dozier, Tex.; very rare.